May, 1894.]

THE

TRANSACTIONS

OF THE

ROYAL IRISH ACADEMY.

VOLUME XXX.—PART XI.

ON THE GEOLOGY OF TORRES STRAITS.

By PROFESSORS A. C. HADDON, M.A., W. J. SOLLAS, LL.D., D.Sc., F.R.S., AND G. A. J. COLE.

PLATES XXII. TO XXV.

DUBLIN:

PUBLISHED AT THE ACADEMY HOUSE, 19, DAWSON-STREET.

SOLD ALSO BY

HODGES, FIGGIS, & CO., LTD., GRAFTON-STREET.

AND BY WILLIAMS & NORGATE,

LONDON: 14, Henrietta-street, Covent Garden. | EDINBURGH: 20, South Frederick-street.

1894.

Digitized by the Internet Archive
in 2026

https://archive.org/details/transactions-of-the-royal-irish-academy_1894-05_30_part-11

XI.

ON THE GEOLOGY OF TORRES STRAITS.

By PROFESSORS A. C. HADDON, M.A., W. J. SOLLAS, LL.D., D.Sc., F.R.S., and G. A. J. COLE.

(Plates XXII. to XXV.)

[Read June 27, 1892.]

CONTENTS.

	PAGE		PAGE
I. Introduction, ...	419	IV. The Central Coral Islets, . . .	450
II. General Account of the Physical Features of Torres Straits, . .	420	V. The Western Islands and their Relation to the Queensland Axis, . .	453
III. The Eastern Volcanic Islands, . .	423	VI. General Conclusions, ...	467

I.—Introduction.

Torres Straits were discovered in 1606 by the Spanish voyager Luis Vaz de Torres, whose name they now bear. They were first partially surveyed by Captain Cook in 1770, and more thoroughly, during the years 1843–45, by Captain Blackwood of H.M.S. "Fly," and in 1848–49 by Captain Owen Stanley of H.M.S. "Rattlesnake." H.M. Cutter "Bramble" was associated with both these ships in the survey. A brief account of the history of the discovery of Torres Straits, and of the subsequent expedition to that district, will be found in Lindt's "Picturesque New Guinea" and Thomson's "British New Guinea."

Professor J. Beete Jukes is the only naturalist who has given us any account of the geology of this region. His descriptions, so far as they go, are characterized by that clearness and accuracy for which that distinguished geologist was so noted. These remarks apply also to his zoological and anthropological observations. It affords us great pleasure to record our appreciation of the work of one who was once the director of the Geological

Survey of Ireland and a predecessor of one of us in the Royal College of Science. The geniality of his character was such that he was remembered in Ĕrub and Mer in 1888, and it was also not forgotten that he had changed names with a young native named Dudĕgab (cf. "Voyage of the 'Fly'," vol. i., pp. 177–8).

In the course of the descriptions of the several islands we shall allude to the geological notes which have been made by other travellers. We have copied and set down in their appropriate place all the geological observations published by Jukes in his voyage, and have examined the specimens brought home by that observer, which are preserved in the collections of the Geological Survey of Ireland.

II.—General Account of the Physical Features of Torres Straits.

We feel that we can scarcely do better than to preface our remarks on the general features of Torres Straits by quoting the following from Jukes ("Voyage of the 'Fly'," vol. i., pp. 152–154):—

"If we take Endeavour Strait, Cape York, and Mount Adolphus [Muri] as a base, all the islands which stretch across the Strait to the northward of them have one common character. They are all steep and rocky, and many of them as much as 500 or 600 feet in height. The rocks of the mainland and the islands immediately adjacent are all porphyritic, like those described as composing Mount Adolphus. Porphyry, sienite, and silicious schists, or compact felspar, compose all the other islands which I visited, or of which I was able to procure specimens. These islands are in fact merely the submarine prolongation of the great mountain chain of the eastern coast of Australia. This chain runs from Van Dieman's Land, through Bass's Strait, into the colony of New South Wales, which it traverses throughout at a mean distance of 70 or 80 miles from the sea. It extends along the whole of the north-east coast, where its loftiest and most massive portion is between Cape Upstart and Cape Melville. From that point its mean height gradually decreases to Cape York, where the hills are only 400 or 500 feet in height, and then sinking below the sea, its highest pinnacles only are seen, forming the islands of Torres Straits, from Cape York Island to Mount Cornwallis [Dauan], on the coast of New Guinea.

"In this central north and south band of Torres Straits there are no independent coral reefs. The coral only occurs in small fringes round the islands. [On p. 332 Jukes adds, 'as far as our examination extended.' As a matter of fact there is an extensive series of reefs between the Prince of Wales group of islands and the opposite New Guinea coast.] The bottom is either mud or fine sand; and there is a remarkable uniformity of depth, which scarcely varies from ten fathoms by more than a fathom or two over the whole distance from the coast of Australia to that of New Guinea. The north-west portion of this band of islands has not yet been examined [1847]; but north of Banks's Island [Moa] and Mulgrave Island [Bădu] there appears to be a large patch of true coral reefs in which the "Hormuzeex" and "Chesterfield" got entangled in 1798. The eastern limit of this central band, however, is very well defined by a line running a little east of north from Mount Adolphus, and just east of Harvey's Rock, Saddle Island, and Turtle-backed Island [Yăm]. To the east of this line there are no islands in which any such rock as porphyry or sienite occurs; but all are low coral islands, scarcely raised above the sea, and multitudes of true independent reefs of great extent are scattered about with considerable apparent irregularity. Having traversed these for sixty miles towards the east, we again come to a few high and rocky islands, namely, the three Murray Islands and Erroob or Darnley Island. These, however, are volcanic islands, consisting principally of lava. Another low island to the north of these, called Bramble Key, or Caedha [Keda, Măsaramker of the Admiralty Charts (*cf.* p. 449)], has likewise a patch of volcanic rock in its centre and another not far from it."

The triple division of the islands of this archipelago, first noticed by Jukes, is very apparent, the lines of longitude 142° 48′ E. and 143° 29′ E. conveniently demarcating these sub-divisions. It should, however, be remembered that, while the volcanic islands are confined to the eastern district, and the old igneous rocks are equally limited to the western area, low coral islets occur in all the three regions, although they alone are to be found in the central zone. Great stretches as well as isolated patches of coral reefs are also plentifully distributed from the western entrance of the Straits to the oceanic edge of the Great Barrier Reef. It is the presence of

these reefs, as well as of the outliers beyond the Barrier Reef, which has given Torres Straits such a bad name in the annals of navigation.

Even at the present day the reefs of this district are very imperfectly charted; many are not laid down at all, and others are somewhat erroneously contoured. These remarks are made in no captious spirit, for no one who has worked with Admiralty charts can fail to be struck with the conscientious minuteness of the work of the surveyors and draughtsmen. The official charts of Torres Straits are no exception, and the channels for the "inner" and the "outer routes" are laid down with all requisite accuracy. There are, however, considerable areas in the Straits which are absolutely uncharted. It is hardly probable, on the other hand, that any practical benefit would be likely to accrue from the completion of this work, though it might be of scientific interest.

There is one line of work which would be important from a scientific point of view, and that is to trace the influence of the great volume of fresh water and of detrital matter brought down yearly by the Fly River on the extensive coral plateau which extends from North Queensland to New Guinea. It would be interesting if it could be determined whether the fluviatile sediment occasionally encroached on purely coral formations, to be in its turn encrusted with a fresh growth of coral.

When one examines the older and the more recent maps of the neighbouring districts of British New Guinea, it is evident that it is a region in a state of continual transformation. To take the delta of the Fly, old islands disappear and new ones make their appearance. For example, a small island named Tree Island is shown in the map illustrating Jukes' "Voyage of the 'Fly'," and it is mapped in all the later Admiralty charts; but Sir William Macgregor, the able and energetic Administrator of British New Guinea states:—"The place marked on the chart as Tree Island, and lying south of Kiwai Island, is not there; if it ever existed, it has been washed away. On this point I can speak with positive assurance."

There can also be little doubt that the delta region of the Fly—which may be taken as extending from about 8° S. and 143° 50′ E. to the western limit of British Territory at the 141st meridian of east longitude—is encroaching on what we termed above the coral plateau, and thus the

connection between New Guinea and Australia is once more being established. Whether they will ever form one continent, as they must have done in past periods, is not for us to forecast. Certainly, in the immediate past, the smallest continent and the largest island were more widely separated from one another than they are at present. That the separation is ancient, and has been long persistent, is one of the most interesting conclusions reached by the German botanist, Dr. O. Warburg,* who has travelled in the eastern and southern seas, and collected plants in order to elucidate the botanical problems of the Monsoon district.

III.—The Eastern Volcanic Islands.

The meridian 143° 29′ of east longitude, and the edge of the Great Barrier Reef, respectively, delimit the eastern division of Torres Straits. This division includes the following islands:—Zăpker (Campbell Island), Uga (or Hoger, Stephens Island), Ĕdugor (Nepean Island), Ĕrub (Darnley Island), Măsaramker or Keda (Bramble Cay), and the Murray Islands, Mer (always spoken of as Murray Island), Dauar and Waier, besides several sand-banks or "Cays," some of which are partially covered with vegetation.

The Great Barrier Reef runs from Raine Islet (lat. 11° 35′) in a general northerly direction some seventy miles distant from the Queensland coast. At first it is east of the 144° meridian, and then it lies west, and about the tenth parallel it passes east again. It terminates from fifteen to twenty miles north-east of the Murray Islands, at what is known as Flinder's Entrance.

The deeper parts of the plateau of the Barrier Reef vary from about fifteen to thirty fathoms. There are no bottom soundings outside the Barrier Reef which would allow of any accurate contour lines being drawn. Forty to sixty fathoms are recorded between Flinders' Entrance and Portlock Reefs. The greater portion of the Papuan Gulf probably runs to about fifty fathoms, deepening to over a hundred fathoms about the ninth parallel. Five hundred fathoms and no bottom are marked at 10° 22′ lat. S., 144° 56′ long. E., and 107 miles south of this the "Challenger" found grey ooze at a depth of 1400 fathoms.

* "Beiträge zur Kenntniss der papuanischen Flora," Engler's Botanische Jahrbücher, Bd. xiii., pp. 230–254, 1891.

The coral reefs in this district of the Straits are extremely numerous and very complex. The depth of the sea, too, is peculiarly irregular. For instance, over 70 fathoms is charted for a small area, about twelve miles north-west of Ĕrub.

The detached coral reefs appear to run in a general N.E.–S.W. direction, varying between N.N.E.–S.S.W. and E.N.E. and W.S.W. There are gaps and channels which run approximately at right angles to the trend of the reefs. There are strong currents in the main channels. At the Murray Islands the tide sets in through Flinders' Entrance.

The most northerly of the reefs in this portion of the Straits is Anchor Cay (lat. 9° 22′ S., long. 144° 6′ E.), which may be regarded as the furthest outlier of the system of the Barrier Reef. If a line be drawn between this and a small detached reef (lat. 9° 22′, long. 143° 51′) fourteen miles N.N.E. of Ĕrub, and again from this to Uga, and then continued along the parallel of 9° 30′ S. to the group of the Warrior Reefs, the area thus cut off from the Straits will be found to be entirely destitute of coral reefs, with the exception of the reefs fringing Bramble Cay. On p. 449 we quote Jukes' description of this reef; and we would remind our readers that the Blue Coral *Heliopora cærulea* is an Alcyonarian and not a Madreporarian coral. We would also draw attention to the fact that Alcyonaria are to be found thriving on spots which are uncongenial or even fatal to the white corals. This northern area corresponds very closely to a segment of a circle, having a radius of 55 miles, the centre of which would be at the mouth of the Fly River in the neighbourhood of the Midge Isles. We may, therefore, attribute the cessation of reefs at the parallel of 9° 22′ to the influence of the Fly River.

Jukes gives a brief account of the geological structure of the Murray Islands and Ĕrub (vol. i., pp. 204–207), in which he accurately describes the character of the volcanic ash and of the geological structure of the islands of Dauar, Waier, and Ĕrub. His description of Mer is somewhat inaccurate, but this was not so much due to error of observation on his part as to lack of opportunity for investigation.

If a line be drawn between Bramble Cay and the Murray Islands it will be found to be about 50 miles (nautical) in length, and to run approximately N.N.W.–S.S.E. A line drawn from Bramble Cay to

Zăpker (Campbell) Island, passes just outside Uga, and measures about 35 miles. A third line from Zăpker to the Murray Islands would be about 40 miles in length. All the recent volcanic islands in Torres Straits are contained within this hypothetical and approximately equilateral triangle, which has a superficial area of 700 square miles. We do not, however, wish to imply that the volcanic activity was coterminous with this triangle. The area may have been larger, but could scarcely have been smaller. It will also be found that if straight lines be drawn from the middle of Ĕrub (Darnley Island) to the centres of Bramble Cay, Mer, and Zăpker, they will respectively measure about 28 miles, 26 miles, and 15½ miles in length. Thus Ĕrub is as nearly as possible in the centre of this triangle.

Bramble Cay, Zăpker, Uga, Ĕrub, and probably Ĕdugor, are composed entirely of lava, with the exception of two small patches of stratified ash in the last. Mer is about equally composed of lava and volcanic ash, while Dauar and Waier consist entirely of the latter rock.

The Murray Islands.—(1) Mer.

We will commence with the Murray Islands, taking Mer first, as it is the largest and most important. Jukes says (vol. i., p. 205)—"In the island of Maer, these beds" [the "stratified volcanic sandstones and conglomerates" which he had just described], "have a regularly quâquâ-versal dip from the centre of the island to the sea, on the north, west, and south sides of it. On the south-west side they were inclined at an angle of full 60° from the top of the island to its base. The upper ends of these beds form a curvilinear ridge, concave towards the interior of the island, where is another hill of a conical form, the composition of which I was not able to ascertain." On p. 195 we read:—"April 11 [1845]. We anchored at ten this morning on the north-west side of the Murray Islands, about half-a-mile from the shore [the anchorage of the "Fly" is still (1889) pointed out by the natives]. I was much struck with the stratified appearance of the rock and the highly inclined position of its beds. The island is lofty and broken, its highest point being 750 feet above the sea. This is a bare eminence, forming a narrow ridge, slightly concave towards the interior of the island, where there is another and lower hill of a conical

form. From the outside of these the ground slopes steeply towards the sea, especially on the west and south sides. It is almost entirely covered with one thick grove of coco-nuts, spreading even over the tops of the lower hills in greater profusion than I ever saw elsewhere. Its size is rather greater than that of Erroob, its greatest diameter being from three to four miles. Its native name is Maer." Lastly, on p. 206, he writes:— "In none of the Murray Islands did I see any traces of lava or igneous rock, except the fragments contained in the conglomerates; igneous rocks, however, may exist in mass in the interior of the islands, a fact which I greatly regretted that time did not allow me to ascertain." From the last remark it is quite evident that Jukes visited only the western side of Mer; and it is probable that he ascended the ridge of Gelam, about one-third from its northern end, by the native track. He could not have reached the peak, or he would have given a better description of the physical features of the island. Surveying parties must have circumnavigated the island in boats, otherwise the chart could not have been made, and we suspect that Jukes inquired of the officer in charge as to the appearance of the island from the other side, and was told it resembled that of the side where the "Fly" was anchored. If Jukes had been round the island in a boat he must have seen the edge of the lava-flow, which extends from the north to the east. More difficult to account for is his statement that the stratified beds of ash "were inclined at an angle of full 60° from the top of the island to its base."

In his small book, "Among the Cannibals of New Guinea" (1888), the Rev. Dr. S. Mac Farlane gives, on p. 83, a short popular account of the physical features of Mer. It would not be fair to criticise it from a scientific point of view.

Mer (lat. 9° 55′ S., long. 144° 2′ E.) is roughly oval in contour, the long axis lying about N.E.–S.W. It is surrounded, except at its south-western end, by a broad fringing reef. The island is 2·79 kilometres in length, and averages about 1·65 kilometres in width; its area is 386 hectares. The area of the great lava-stream, which occupies the eastern half of the island, and the alluvial soil between the hills and the sand beach, are more or less under cultivation. This portion of the island is

very fertile, and supports a luxuriant vegetation, which, when left to itself, forms an almost impenetrable jungle. Coco-nut palms grow in profusion; and the natives plant bananas, yams, and sweet potatoes. There are also wild mangoes and other wild fruit-trees. The great crescentic valley, at the south-western end of the island, being formed in a porous volcanic ash, and being somewhat arid, is by no means so fertile; the vegetation, which consists of grass, low scrub, and scattered coco-nut palms, presents a marked contrast to the remainder of the island (Pl. XXIV., fig. 1). The slopes of the hills are usually bare.

The most prominent feature of Mer is the long steep hill, Gelam, which culminates in a peak 750 feet in height. Gelam extends along the north-west border of the island. It is 1375 metres long, and at its northern end terminates in a low hill named Zomar, which splays out into

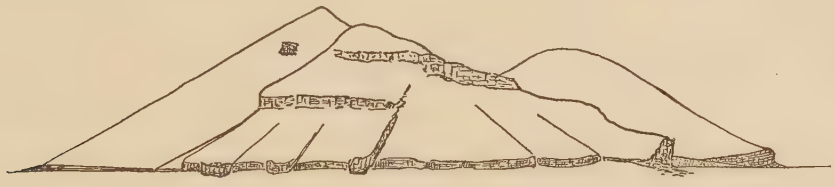


FIG. 1.—Sketch of the south-west end of Mer. Below the peak of Gelam is "Gelam's Eye," the low projecting cliff to the left is Begnĕb, the one below the right hand end of the lower escarpment is Gelam pit, and the prominent one to the right is Nemer pit; beyond this is the sand-beach of Werbadu, and above this is the hill Dĕbĕmad.

two spurs; the outer is called Upimager and the inner Mĕkernurnur. The beds of this spur are inclined at angles from 20° to 30°, and slope towards the valley, that is in an opposite direction from the beds of the other spur. The hill Gelam rises up from a narrow belt of cultivated soil behind the sand beach, at an angle of 30 degrees, forming a regular even slope, covered with grass, save for occasional patches of bare rock. At the western end the ground is much broken, as can be seen on reference to the sketch. The termination of the smooth portion is marked by a conspicuous curved escarpment; beyond this is a prominent block of rock, about half-way up the hill. This is known as "the eye." The whole hill, seen from the sea at some distance, bears a strong resemblance to an animal, and the natives speak of it as having once been a

dugong, the history of which is enshrined in the legend of Gelam, a youth who is fabled to have come from Moa. The terminal hills at

Fig. 2.—Sketch of the hill of Gelam from the south end of Mĕbgor reef. The tree on the extreme left is on the beach at Kiam; near this is the jetty at Zauub; a tree is drawn on the top of Zomar; the grove of coco-nut palms is at Umar; at the other end of the island is the stream at Pas; further on is Nem (the lower end of the paddle of the dugong); the point at the end is Gelam pit ("Gelam's Nose").

the north end of Gelam represent the lobed tail of the dugong, the curved escarpment corresponds to the front edge of its paddle, while the eye and the broken ground which indicates the nose and mouth complete the head. The broken ground below the peak of Gelam forms a precipitous shore-line, with many fallen boulders.

A little to the south of the western point of the island is a deep valley, down which a stream rushes after rain, and which drains the greater portion of the large valley. The small valley is called Werbadupat; beyond it rises the symmetrical hill Dĕbĕmad, which passes into the hill Mergar. The latter corresponds to Gelam on the opposite side of the island; it terminates in the steep hill Pitkir.

It will be seen that Gelam and Mergar form a somewhat horseshoe-shaped range, the continuity of which is interrupted at its greatest bend, and it is here that the ground is most broken up. The rock is a beautifully stratified volcanic ash with a quaquaversal outward dip of 30 degrees. There can be no doubt that this is the margin of a crater, the whole eastern lip of which has been breached. The crescentic valley, crater, or "big valley," is a slightly concave valley with gently sloping sides, except where the higher part of Gelam rises up in a steep slope surmounted by fractured precipices (Pl. xxiv., fig. 2). There are several small lumpy hillocks at the southern end of the crater, and a low ridge, Mamsĕp, connects Gelam with the smaller horseshoe-shaped hill, which is the remains of the central cone of the old volcano. The western limb of the cone is named Zaumo, and the eastern Gur. Zaumo is prolonged into a spur known as "Ai."

In the valley, Deaudupat, between these hills and Gelam, and north of the Mamsĕp ridge, arises a stream which flows in a northerly direction, and, after receiving two other affluents, empties itself into the sea a short distance beyond Zomar. It should be remembered that the beds of these streams are dry for the greater portion of the year, and it is only during the rainy season, *i.e.* from November to March, and then only immediately after the rain, that the term stream can be said to be applicable to them. There are, however, some water-holes in the bed of the stream, which hold water for many months. Towards the lower portion of its course, in the neighbourhood of Zomar, the stream has carved for itself a relatively deep gorge, and here forms cascades. As in Werbadupat and Erpat, the cascades occur where a bed or dyke of lava offers more resistance to the attrition of the stream than do the soft layers of the volcanic ash. The lava here is distinctly decomposed. In a narrow part of the gorge which has been cut through the volcanic ash is an interesting fault of small throw. Here also was seen a large ejected block of lava which had plunged into and displaced the ash.

A little lower down, at Wezai, is an enormous pot-hole, 13 feet 6 inches long, by over 10 feet across; the circumference is at least 33 feet, and the depth measured at the outflow is 8 feet.

Shortly after this, the stream passes into the small delta which extends from the base of Zomar northwards to the point Momoterkĕk.

The great lava-stream extends with an undulating surface from the central cone to the northern end of the island. It forms a fertile table-land, which is bounded by a steep slope. On its west side this slope is practically a continuation of the sides of the central cone, and bounds the eastern side of the delta as far as Momoterkĕk. At the northern and eastern sides of the island the lava-stream forms an abrupt or steep declivity, extending either right down to the water's edge, or occasionally leaving a narrow shore.

At the most northerly point—Momoterkĕk—of the island the lava forms a cliff, and there are patches of lava *in situ* on the beach. Then, to the eastward, is a pretty little sandy bay, Mĕk, at the eastern side of which is a low precipice, named Wed. Here there is a small cave, called

Werisweris-kur. The lava is jointed in concentric shells, one of which forms the roof of the cave, while the floor consists of the underlying scoriæ. The rocky coast continues to Pitkĕk. At the north-east angle of the island there is a long sandy foreshore, on which is built the village of Ulag. Between tides on the beach at this point are numerous patches of lava.

The eastern side of the island may be said to commence at the rocky point of Lewer. Five hundred yards to the south is another lava cliff, called Gazir, and between them is a sandy beach, on which is the large village of Las. Here the beach is fairly wide, owing to a break in the lava-stream. The small valley thus caused is increasing through denudation. Between the villages of Las and Er are, at least, four spots where the lava-stream appears as precipitous, rocky points, which are named Gazir, Wabkĕk, Turpit, and Wemer pit, and between these are the sand beaches which are respectively called Murbu, Arĕb, and Ĕger. The photograph reproduced as fig. 2 on Plate xxiii. was taken at low tide at Wemer pit. The lava is seen bared on the beach at low tide, and in the distance are seen Dauar and Waier.

A deep valley, Erpat, which terminates in a gorge, separates the southern end of the lava-flow from Pitkir, and from the spur of Gur. The following is an extract from notes written on December 5, 1888, immediately after a visit to Erpat:—"The gorge is cut by a stream which flows down it only during the rainy season, or 'Nor-west.' At the top it is merely a narrow, shallow channel for the stream, the bed being of loose boulders of lava. Further on there are several cascades; then the bed narrows, and it cuts deeply through the inclined beds of ash. The bed of the stream is steep, and every now and again there are elongated basins, which are evidently a kind of pot-hole. The cascades or waterfalls are caused by beds of hard lava (*a*), overlying a more spongy lava (*b*), which breaks up into irregular blocks, and is mixed up with much earthy matter. Below this, in one instance, was a bed of stratified ash (*c*) of a buffy-yellow colour, containing numerous small fragments of lava. Below this again was another layer of compact lava (*a*), and under this a band of the vesicular lava (*b*). . . . The second portion of the gully is cut solely

through highly inclined stratified volcanic ash." Here we have an interesting insight into the structure of the wall of the crater.

The bed of the stream in Werbadupat commences suddenly, and is at first shallow, with only a few boulders in its course. Soon it follows a lava-stream. This lava exhibits flow-markings in places; and there are often to be seen concentric coils of the pahoe-hoe type, which appear to indicate the swirling round of the lava as it was cooling. Later, a bed of scoriæ is reached. This has the usual character of irregularly-shaped fragments imbedded in a red earth. Lastly, the course is carved through the stratified ash. These beds do not exhibit a regular outward dip. At the line of junction of the dyke with the loose scoriæ, or bed of rubbly lava, the lava exhibits a fissile structure roughly parallel to the line of contact.

The fringing reef extends all round Mer, except at its south-western end; the extent of the reef will be best understood by referring to the map (Pl. xii.). The broadest portions are to the north-east, and at about the middle of the east side. There is a remarkable spur to the north-west, opposite the spot called Korog (where the cemetery is), and due north of the mouth of the principal stream. On the south-eastern side, opposite the village of Er, there is a somewhat similar break in the reef, but with this difference, that here the reef, after being indented by a deep inlet, extends out nearly as far as before, and only gradually approaches the shore line towards the west.

Opposite the village of Zauub (where the track, "big road," passes over the hill Gelam to the interior of the island), which is situated at about one-third of the length of the island from the south-western end, and on its north-western aspect, the edge of the reef is steep, with rounded masses of corals, among which are explanate Madrepores, small groves of branching Madrepora, Pocillopora, and Seriatopora, and masses of Astræa, and Brain-coral.

Towards the north the edge of the reef is decreasingly luxuriant, so that opposite the hill Zomar, the Madreporaria are practically replaced by Alcyonaria. This is evidently due to the influence of the stream which enters the sea close by. The same general character obtains till the above-

mentioned spit is reached, where the Madreporaria again occur in profusion. The northern side of the spit is characterized by the great luxuriance of the growth of the corals, the edge of the reef here being very steep, vertical, or even overhanging. These features are continued all round the reef to opposite Er, on the south-eastern side of the island; here the broad plateau of the reef takes a shoreward bend, and with a more gradual slope of the seaward edge of the reef the corals are less luxuriant. The reef remains uninteresting for some distance, and it approaches the shore, and disappears opposite the hill Dĕbĕmad. Between this spot and Pas, which is the first point of land west of the curved escarpment at Nĕm, there is no distinct fringing reef, though corals do grow in places.

The reef recommences at Pas, and possesses the same general appearance which it has at Zauub. Zauub adjoins the now-deserted Mission Station.

We are justified in assuming that the reef is increasing towards the north and east; in other words, in the region which is washed by the tide which sets in down Flinders' Entrance. Where the hills form a steep coast-line, as at the south-western end, the coral reef is absent.

The two gaps, the one on the north-western and the other on the south-eastern (Pl. xxiv., fig. 1) aspect of the island, appear to be directly attributable to the action respectively of the stream which arises in Deaudupat and that which flows down Erpat. Although no water flows into the sea during eight months of the year, and only intermittently during the remaining four, yet there is sufficient fresh water poured on to the reef to check the coral growth and to affect the character of the zoophytic fauna. The shape of the northern gap, with its abrupt spur, is evidently also due to the combined influences of the current from Flinders' Entrance, on the one hand, which stimulates coral growth, and the destructive action of the stream on the other. The current enables the coral to grow luxuriantly as close as possible to the fresh water, and also carries down the freshened and muddy water to the south-west; and this accounts for the character of the reef opposite to the hill Gelam.

The volcanic rocks of Mer are distinctly basaltic, and are marked by a development of porphyritic crystals of olivine and monoclinic pyroxene.

This is, indeed, the character of all the volcanic materials collected in the eastern islands of Torres Straits. While the texture of typical glassy andesites is often present, the rocks are more basic in character than the well-known andesites of Java, and must be classed as olivine-basalts. Similarly vitreous basalts occur also in the Javan area*; although neither there nor in Torres Straits do crusts of black glass of the Sandwich Island type occur on the surface of the flows.

The great stratified ash-beds, of which the crater-wall of the western end of Mer is so largely composed, prove clearly the violent nature of the explosions that built up the island. The lava-fragments are comminuted, often to a mere brown pumiceous dust; and particles of the foraminiferal and coral limestones are abundant, torn from the earlier deposits through which the volcano broke. The history of volcanic islets must be one of continual destruction and reconstruction, though only the latest products may be exposed; and the coral-banks, shattered by one series of eruptions, supply materials that are used again and again in successive cones. Thus, the large blocks of compact white limestone, often distinctly crystalline, in the tuffs of the summit of Gelam may have been blown out by an early eruption and may have been brought to their present position during some later re-arrangement of the materials. However that may be, the coral plateau of the straits probably existed before the outburst of volcanic action; and limestone thus forms no small part of the ejected materials which were finally piled above the sea-level.

Analysis shows a fragment from the summit of Gelam to be largely dolomitic; and in section it exhibits a fine mosaic of rhombohedral dolomite, full of contraction-cavities, cracks, and interspaces, which are lined with small rhombohedra of dolomite projecting into them. The cavities are occasionally filled with calcite, and doubtless, in most cases, represent the space once occupied by a fragment of some organic skeleton.

In the finely-grained ash of the gully of Erpat, numerous dusky-brown spheroids occur, 5 to 8 mm. in diameter, showing sometimes a concentric structure. These are not concretions in the ash, for they do not include

* Rosenbusch, "Ueber einige vulkanische Gesteine von Java." Ber. über die Verhandl. der naturforsch. Gesell. zu Freiburg i. B. Bd. VI. (1876), pp. 77 and 110.

the coarser vitreous or crystalline materials. They appear to be similar to the little pellets found in the fine volcanic dust of Pompeii, and to owe their origin to the rolling of particles of consolidated and probably moistened ash over still uncompacted volcanic dust, where they pick up the latter, and thus grow larger in their progress. Some layers of the ash of Mer are much richer than others in these pellets. If the above suggestion is correct, a local combination of wind and rain would tend to produce them.

Under the microscope (Pl. xxv., fig. 4) the ash of Mer shows numerous torn and broken crystals of brown pyroxene and colourless olivine, which were the porphyritic constituents of the glassy lavas in the vent. Many of them retain traces of glass around them; and the groundmass of the lava is everywhere to be seen in the brown-green palagonitic and scoriaceous fragments which form the darker constituents of the ash. The colour of the whole rock, as seen in the mass, is lightened by the presence of calcareous particles, by the extreme comminution of the pumiceous dust, and by the orange decomposition-products of many of the glassy fragments. The central cone of Mer yields specimens, as might be expected, of coarse scoriæ and bombs; one of the latter, collected on the top of Zaumo, measures 25 cm. in length.

It has been pointed out that lavas form part of the structure of the crater-ring, as may be seen in the ravine of Erpat; and representatives of the compacter portions of these occur also among the ejected blocks. These dark grey rocks prove under the microscope to be handsome olivine basalts, with olivine and augite as porphyritic constituents. In a block from the top of Gelam, the groundmass is a yellow-brown glass, crowded with granular pyroxene and delicate unaltered plagioclase. The pyroxene microlites are beautifully idiomorphic, and there is no tendency to an ophitic structure. The felspar prisms often show characteristic incomplete and bifurcating terminations. Patches formed by microlites of magnetite, oriented parallel to one another, appear in the glass, together with larger opaque grains.

The scoriaceous lava of the gully of Erpat, on the east side of Mer, is not so rich in porphyritic crystals, and has a very beautiful dark-brown

glassy matrix, in which little cubes of magnetite have developed, while needles of pyroxene, arising later than the felspar, have attached themselves to the surfaces of the latter mineral. The rock reminds one of the augite-andesite of Eskdalemuir in Dumfrieshire*; but the porphyritic olivines proclaim its more basic nature. Although it seems most simple to rely on the presence of olivine, not as a mere occasional constituent, but spread through a rock-mass, as a means of distinguishing basalt from basaltic andesite, we must, of course, admit that a perfect similarity may exist between the structures of the groundmass in certain specimens of one group or the other.

At Wed, at the northern end of the great lava-flow from the central cone, the rock is a typical basalt, with granular pyroxene in the groundmass, and with only a small proportion of pale residual glass.

In the exposure of lava in the gully of Werbadupat, to the south of the island, the rock is speckled over with white patches about 2 mm. in diameter, resembling felspathic spherulites. As is so often the case, this differentiation of the groundmass disappears in a thin microscopic section, except in so far as a local increase in the proportion of the darker augite granules can be here and there detected. The nearest European representative of this structure, so far as we are aware, occurs in the lava quarried on the high road just above the Roche Sanadoire, Mont Dore; but the same tendency to spherulitic structure, obvious enough in the mass, but difficult to account for under the microscope, is seen on a larger scale in the "Kugelgrünstein" of the Stefanschacht of Selmeczbánya, Hungary, and in the andesite on the summit of Aran Benllyn in Wales.

The lava of Werbadupat is also remarkable for the alteration of certain of the crystals that have been floated up within it. As in so many andesites, the porphyritic hornblendes have suffered from complete disintegration and internal recrystallization,† the products being minute prisms of colourless and brown amphibole, with magnetite and interstitial plagioclase.

It is clear, then, that Mer owes its form mainly to its volcanic origin.

* Sir A. Geikie, Proc. Roy. Phys. Soc. Edinburgh, vol. v., p. 29.
Teall, "British Petrography," Plate xxiv., fig. 1.

† See for example, Teall, "British Petrography," p. 260.

The outer ring from Zomar to Pitkir is the relic of a cone formed in the earlier periods of activity, the ash-beds dipping out towards the sea on all sides. The crescentic valley is half of the old crater, formed probably by a paroxysmic eruption that reduced the height of the whole island. The hills of Zaumo and Gur represent the later scoria-cone thrown up above the vent by milder and reconstructive action. But the volcano passed from the explosive stage to one in which the basaltic lava flowed from the vent through the loose and crumbling walls, carrying away the N.E. side of the cone and whatever may have remained of the crater-ring in that direction. This lava reached the sea, reminding one of the Rocche Rosse flow in Lipari, descending through the breached cone of Monte Pelato; and at the present day the extinct volcano is undergoing decay by denudation. The lavas and scoriæ are being converted on the beach into pebbles, which become embedded in the modern coral and foraminiferal sand. At the east side of the island a most interesting rock is being formed by an intermingling of blown coral detritus and the porphyritic crystals weathered from the great basalt flow. This deposit has been already discussed by two of the present authors*; the dark silicates embedded in the matrix of pale yellow or pinkish limestone, which has become compacted, and which appears almost homogeneous to the naked eye, present a contrast rarely met with, and forcibly remind one of the "hemithrenes," and especially of the Sahlite limestone of Tiree.

Under the microscope, rounded fragments of glassy lavas appear, in addition to crystals of pyroxene, olivine, and felspar. There are also fragments of an older and compacter limestone; these and the rounded remains of nullipores, foraminifera, echinoderms, and other organisms, are penetrated by boring algæ. The calcareous mud has crystallized, so as to produce a fringe of acicular calcite prisms around each of the embedded fragments, the ends of one set interpenetrating among those radiating from another centre, and thus binding the whole mass together. When this structure arises round a calcareous granule, the prisms in the cementing material develop in optical continuity with the calcite crystals of the fragment, the

* Sollas and Cole, "The Origin of certain Marbles."—Proc. Roy. Dublin Soc., vii. (1891), p. 124.

true outline of the fragment being thus concealed, except for its more dusky appearance when examined in polarized light. Similar growths of calcite have developed within the chambers of some of the foraminifera, and the whole of this beautiful structure is clearly similar to that recently described by Mr. Harker,* as occurring in the Tonga Islands. (See Pl. xxv., fig. 6).

The Murray Islands.—(2) Dauar.

The two islands of Dauar and Waier are almost contiguous, and are enclosed by a single fringing reef. They lie south of Mer, and are separated from it by a channel 1982 metres wide, which averages twenty fathoms in depth.

Jukes says (vol. i., p. 205):—"Of the structure of Dowar, I can only say that it is formed of beds of precisely the same appearance as those of Maer; that they are inclined at great angles, and dip outwardly from the interior of the island on its north and east side."

Dauar is a small island shaped something like the figure of eight. It is about 1580 metres long and 762 metres broad at its widest or western end. It is composed of two hills, Au Dauar (605 feet in height), and Kĕbĕ Dauar, or the Great and Little Dauar, with a sand-spit at each end—that at the west end is called Kameri, the point at its end is known as Giar, and the spit nearer to Waier is named Teg. The hills, especially their upper portions, are covered with grass and bushes; but the neck of low land between them supports a luxuriant vegetation. The two hills (Pl. xxiii., fig. 2) have an even slope on the sides facing one another, but their other aspects are quite steep, and even precipitous in places; this is especially the case in the great cirque on the south-eastern side of Au Dauar. At first sight this appears like the side of a crater. Geologically the island is composed solely of volcanic ash, which precisely resembles that of Mer. The beds incline at the base of Kĕbĕ Dauar from 15° to 35°, averaging 25° to 30°. Those of Au Dauar have about the same angle. Unfortunately

* "Notes on a Collection of Rocks from the Tonga Islands."—Geol. Mag. (1891), p. 253.

no notes as to the direction of the dip of the beds can now be found; but it was observed that the construction of the island was somewhat puzzling.

The Murray Islands.—(3) Waier.

Jukes describes Waier in the following terms:—"A circular island, bounded by steep cliffs, on the top of which was a line of broken crags [Pl. xxiii., fig. 1] looking like a ruined wall surrounding a central hollow. On the north end of this also was a small sand-flat, from which a shoal-bar stretched, dry at low water, and then connecting it with Dowar" (p. 201). "Waier is probably not more than 300 feet high, formed of a circle of nearly perpendicular cliffs" (p. 196). "Waier is likewise composed of the same beds, but containing more conglomerate than those which I saw on Maer, and for one-half its circumference has a regular quâquâversal dip from its centre, but not at a greater angle than 10° or 15°" (p. 206).

Waier is a crescentic islet, and 610 metres in diameter. On its convex side, which faces north-west, there is a small sand-spit also called Waier (Pl. xxiii., fig. 1), the base of which, like the larger one (Kameri) at the corresponding end of Dauar, is covered with vegetation.

The island is entirely formed of stratified volcanic ash, usually dipping outwardly with an average inclination of 15°. But there is a good deal of variation in the dip; one mass of rock dipped at an angle of 15° to the east. On the S.S.W. side the beds appear to dip E.S.E., at an angle of about 10°. The ash is, as a whole, much coarser than that of Mer and Dauar, and in many places it forms a characteristic agglomerate.

It is evident that Waier is the remains of an old crater, which is breached towards the south-east. The walls of the crater facing the interior are practically vertical. Their general appearance is seen in the accompanying figure, which is a sketch taken from near the centre of the crater, on the shore, and looking towards the south-east. The great mass of rock in the foreground appears to have fallen down from the wall of the crater. Externally the walls rise steeply, and are greatly furrowed and fissured. The gullies are vegetated. There is a small sand-beach (Tĕkor

or Tikor) on the north side, from which access can be made by some rather steep climbing to a ledge which runs to the north-western aspect of the island. This ledge is bounded on its southern side by a narrow wall of rock, which here forms a kind of castellated battlement.

Waier is surrounded by a reef which is continuous with that fringing Dauar. It extends for a considerable distance towards the south-east, over the region which was once occupied by the crater; this portion is called by the natives Auter; it dries at low spring tides. There is a sand beach along the north-western end of the concavity of Waier, the inner border of which supports a small patch of luxuriant vegetation.

On the northerly side, opposite the sand-spit, the reef slopes rapidly, with rounded masses of fairly luxuriant coral, and occasional groups of

Fig. 3.—Sketch of the interior of the crater of Waier.

bright-green Sarcophyton, which look like submarine cabbages. Opposite the cliffs, which rise precipitously on the north-east side of the island, the reef is vertical, with explanate Madrepores. The luxuriance in growth is doubtless due to the tide coming from the north-east. This continues to the end of the large reef Auter, on the south-east side of Waier, where there is a steep slope with small clumps and growths of coral. On the south side the reef is again vertical, but the coral growth is not so luxuriant as on the side facing the channel between Waier and Mer. Two or three yards from the edge of the cliff a depth of twenty-four fathoms was obtained.

On the lee-side (*i. e.* in reference to the prevailing south-east monsoon) of the bay, in the reef to the south-west of Waier, the slope is gentle, with corals in isolated patches. On the other side of this little bay the coral becomes more massive, until opposite Kĕbĕ Dauar, when once more the edge of the reef is vertical and the coral luxuriant.

While blocks of coral-limestone are conspicuous among the tuffs of Mer, they form a far larger proportion of the volcanic wall of Waier. The rock even resembles in some places a brecciated limestone; and one is reminded by the part played by the old floor of Devonian slate in the construction of some of the volcanic cones in the Vorder Eifel. But true volcanic material is, of course, everywhere noticeable. One of the specimens collected contains superb examples of pumiceous basalt-glass (Pl. xxv., fig. 5), ragged at the edges, and full of vesicles, and yet retaining the porphyritic olivines and augites which ally them to the ordinary lavas of these islands. The pale brown glass in these tuffs is comparable to the best types from the Sandwich Islands; so that, in the limited area of the Murray Islands, one can illustrate the complete series from tachylyte, containing only scattered microlites and cumulites, to olivine-basalt in which glass is almost absent. In the tuff of Waier, however, orange alteration-products have already developed in some of the glass-fragments, spreading from the surface or from the walls of the vesicles, as in the typical palagonite-tuffs of Sicily and Iceland.

The ejected blocks of coral are often strikingly crystalline, much of the original structure having been destroyed; but it is unsafe to refer such alteration to the metamorphic action of the volcanic neck. As an example, we may refer to the partial disappearance of the coral-structures in the compact and crystalline limestone of the raised reef of Udjong-Tji-Laut -örön, Java.* Mr. Maitland notes, however, the rarity of coral-fragments in raised reefs, even when molluscan remains are found.†

Some of the blocks included in the tuff consist of entire or broken skeletons of a great variety of organisms, both vegetable and animal, such

* Von Richthofen, "Ueber Mendola-Dolomit und Schlern-Dolomit."—Zeitschr. d. deutsch. geol. Gesell. Bd. xxvi. (1874), p. 245.

† Geol. Observations in Brit. New Guinea in 1891, p. 10.

as joints of Halimeda and Lithothamnium, tests of foraminifera, both perforate and imperforate, fragments of skeletons of polyzoa, hydrocorallines, brachiopods, and echinoderms. It is interesting to note that the test of the imperforate foraminifera is without action on polarized light, from which we may infer that its calcareous constituent exists in chemical combination with organic material. In the case of the perforate foraminifera, the wall of the test consists of fibres or pillars of calcite, each having its optic

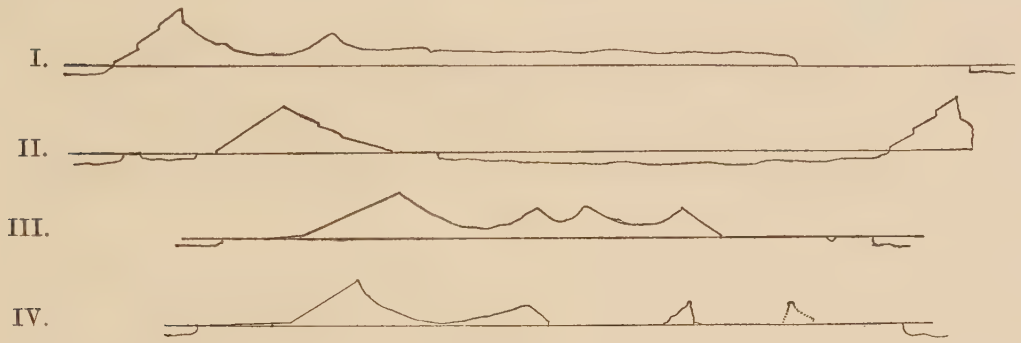


Fig. 4.—Sections through the Murray Islands drawn to the same scale as the Map (Pl. xxii.). The vertical heights are not exaggerated.

I. Section along a line passing across the broadest part of the north-east reef, through Ulag, along the lava flow, through the central cone (Zaumo), across the crescentic valley, and through the peak of Gelam.

II. Section from the peak of Gelam, through the peak of Au Dauar; to the left it passes across the reef of Lĕblĕbkĕp.

III. Section across Mer along a line passing through Umar, the middle of Gelam, Zaumo, Gur, and Pitkir, and cutting the emargination of the fringing reef caused by the stream from Erpat.

IV. Section along a line drawn through the peak of Au Dauar to the peak of Kĕbĕ Dauar, and from thence through the centre of the crater of Waier. The absent south-eastern wall of the crater of Waier is indicated by dotted lines.

axis normal to the surface, and the incrusting carbonate of lime, which has been deposited since the death of the organism, and which now cements it to adjoining fragments, is in complete optical continuity with it, the molecular structure of the secondary deposit being a conformal extension of that of this test. So, too, in the interesting case of the calcitic network of the echinoderm skeleton. This, though organic in form, is crystalline in structure, its molecules being oriented in a direction which is definitely

related to the form of the skeletal organ. The calcite deposited on this has completed the crystalline growth, and given to the network the crystalline form which organic influences had kept in abeyance. Hence the network becomes converted into a congeries of rhombohedra, the solid angles of which, projecting from the surface, give it a roughened appearance, forcibly recalling that of sugar-candy. This continuation of original growth, of course, does not take place in the imperforate foraminifera; and on this account, as well as by reason of their markedly different optical characters, these forms present a remarkably clear and sharp outline against the surrounding calcitic matrix.

The sections given in fig. 4 (p. 441), through the Murray Islands, in various directions, will assist towards a better comprehension of their general topography.

Independent Reefs near the Murray Islands.

No reefs are known to occur between the Murray Islands and the Barrier Reef, a distance of four miles to the eastward; nor are any reefs charted to the south, save those belonging to the system of the Barrier. To the north-east also, there is a clear passage for about two and a-half miles; this passage leads out in a north-easterly direction through the reef and into deep water beyond; it is the well known Flinders' Entrance. The entrance is greatly complicated by reefs slightly to the west of the Murray Islands.

From the Murray Islands to our arbitrary western limit, which we adopt for this division of the Straits, is an intricate assemblage of uncharted reefs. There appear to be at least three navigable channels from the Murray Islands; one which leads to Ĕrub in a fairly direct course; another is the Cumberland Passage, which opens out near Half-way Island; and a third, which is rarely, if ever, used, runs southerly, within the Barrier Reef, for some distance, and then bears across to Cape York.

Most of the reefs near Mer have a general N.E.–S.W. direction. The largest of those is called Mĕbgor by the natives, and lies north-west of Mer at a distance of about 915 metres. It is a very complicated reef with numerous bays or indentations and several lagoons. There is one snug

little bay on the side facing Mer, and about opposite to Umar, which affords a safe anchorage during the south-east monsoon.

Mĕbgor partially dries at low-water spring tides. The south-east side, or that facing Mer, slopes gently, with a sandy bottom, and sparse, small growths of Pocillopora, Seriatopora, Madrepora, and other corals ordinarily found in similar situations. The top of the reef has the same general character. The bays, too, have a sandy bottom. The north-west side offers a marked contrast; here the slope of the reef is very steep, in places vertical or overhanging, with a luxuriant growth of madrepores and other corals. The deep channel beyond is practically a continuation of Flinders' Entrance. The north-easterly point of Mĕbgor is called Urikek by the natives.

To the south-west of Mĕbgor are two or three small patches of coral, Mĕkermot, Ubasikaik, &c.; and a short distance from these again is a group of three small reefs, which are known as Makagar, Kĕs, and Keud.

Makagar is much broader to the south-west, and stretches as a narrow spit towards the north-east. It has a gentle slope to the north, which is destitute of coral; the slope is steeper to the north-west, but still with very little living coral. There is a steep slope on the south-east aspect, which is covered with broken and scattered living corals.

Kĕs is a very narrow reef with steep sides, the living corals being more abundant on the south-east side.

Keud has the same general structure as Makagar. Opposite Mer, or about E.N.E., the slope of the reef is steep, with broken, dead corals, among which living corals are scattered. The corals are more thriving towards the open channel between Mer and Dauar. Towards Dauar, that is to the south, there is a steep incline with a moderate growth of coral. On the north-west aspect the slope is very steep, often vertical, but practically with no corals. On the northerly side of the spit which juts out in the direction of Mer, there is a gentle incline, with no growth of corals to speak of. The edge of the reef has a fringe of growing corals; there is clear water between Keud and Mer on the one side and Dauar on the other. The nearest point of the spit of Keud is about 732 metres from the former; it lies about opposite to the "Eye" of Gelam. The south-westerly end of Keud is about 1570 metres from the tip ("Giar") of the westerly sand-spit of Dauar.

In the deep, and otherwise quite clear channel between Mer and the Dauar-Waier reef are two small coral patches, Etkĕp and Beaudikĕp.

Ĕtkĕp is a linear reef, about 260 metres in length, running almost due east and west. It lies 610 metres and 473 metres south of Gelam pit and Nemer pit, respectively.

Beaudikĕp is a small round patch some 396 metres south of Terkur, the eastern shore-point of the small conical hill of Dĕbĕmad. It has a very steep, nearly vertical slope, all round its circumference, except on its western aspect, which has a more gradual slope with dead coral. Everywhere else there is a rich coral growth, especially at the eastern and south-eastern sides, where there are luxuriant branching madrepores.

South-west of Dauar, and at a distance from the shore-line of 244 metres, are two coral patches, which the natives have named Lĕblĕbkĕp and Wĕskĕpukĕp.

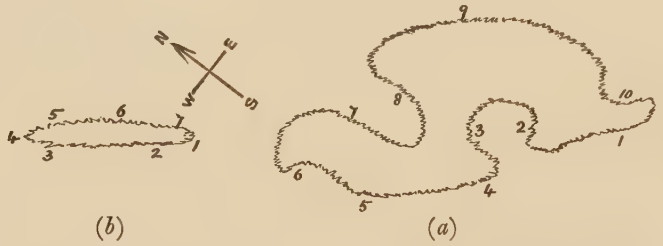


Fig. 5.—Sketch plan of the reefs Wĕskĕpukĕp and Lĕblĕbkĕp.

Lĕblĕbkĕp, which lies about S.S.E. from the peak of Au Dauar, is somewhat S-shaped, with a general lie of east and west. Figure 5 (*a*) may be taken as roughly representing its configuration; the numerals refer to the following:—

1. Steep slope, with small corals.
2. Very steep slope, with dead coral.
3. Steep slope, with small branching living corals.
4. Steep slope, with fine branching madrepores.
5. Steep slope, with small clumps of corals.
6. Steep sandy slope.
7. Gradual sandy slope.
8. Steep sandy slope.
9. Sandy slope.
10. Vertical, with luxuriant corals.

Wĕskĕpukĕp is a small linear reef (figure 5 (*b*)) which lies a little north-west of the former. It bears about south-west from the peak of Dauar, and has a general N.W.–S.E. direction. The numerals refer to the following:—

1. Nearly vertical slope, with Astræas, explanate madrepores, and madrepores which grow in vertical ridges, and other corals.
2. Steep, with fine branching madrepores.
3. Very steep, covered with corals.
4. Moderately steep, even slope to edge of reef, with very little live coral.
5. Steep slope, with living corals.
6. Vertical, with luxuriant growth of corals.
7. Vertical, with numerous corals of various kinds.

Ĕrub.

Ĕrub, or Darnley Island, is somewhat quadrilateral in contour, and is, according to the chart, about two miles long by about one mile broad; but Jukes describes it as being somewhat larger; in either case it is the largest of the recent volcanic islands in Torres Straits.

Jukes describes Ĕrub as "lofty and broken, rising more than 500 feet above the sea, but covered with vegetation." (vol i., p. 169). "The south side of the island is by far the finest. It has beautiful grassy slopes, from the woody summit of the hill down to the belt of wood along the shore. The coast is indented by sandy caves, separated by little rocky headlands, and in each cove is a small group of huts under the shade of a grove of coco-nut trees" (vol. i., p. 181). "The whole island is a mass of igneous rock, from the summit to the sea-shore, with the exception of a small portion of its N.W. side. Here, in the cliffs of Treacherous Bay, the stratified sandstone and conglomerates make their appearance from under the igneous rocks,

dipping towards the interior of the island, or S.E., at a slight angle, not more than 5° or 6°. The igneous rock is a heavy, dark-coloured, hornblendic trap, generally compact, but here and there slightly cellular, or having a few dispersed crystals. On the north-east side of Treacherous Bay the cliffs showed the igneous rock, resting on the sandstones, and it appeared to have flowed over them as lava. The sandstone was not apparently altered, but the igneous rock was much more cellular and cinder-like than usual for two or three feet above the sandstone, when it gradually recovered its compact amorphous character. As previously mentioned the summit of Erroob has a small hollow which might be taken for a nearly obliterated crater, but there is only the slight evidence of form in favour of such a supposition" (vol. i., pp. 206–7). "There was a slight hollow on the summit, surrounded by a ridge of higher ground, but I could not say that it had been a crater; neither was the hill regularly conical, but rather a broken ridge, higher in the centre than elsewhere. The rock was a heavy, dark, rather crystalline lava, or trap, slightly cellular occasionally" (vol. i., p. 186).

The foregoing extracts from Jukes will give some idea of the physical features of this beautiful and fertile island. Save for the rocky headlands, which separate lovely little bays fringed with white coral sand, the whole coast is skirted with groves of coco-nut palms and occasional patches of mangroves. An almost impenetrable jungle clothes the hills, except at those spots which have been cleared for "gardens." Even the tops of the hills are covered with trees.

The crateriform hollow referred to by Jukes appears to be a col on the south-western aspect of the largest hill to the west. It is probable that it owes its form simply to local denudation, no traces of other rock than basalt could be seen on its circumference.

Jukes's statement that tuff occurs only at Treacherous Bay on the north side of the island was not verified, but we have no doubt that such is the case.

There are two beautiful engravings of Ĕrub, drawn by Melville on pp. 169 and 244, of Jukes's "Voyage," but the latter, which represents Treacherous Bay, does not give any indication of these beds. There is,

however, a confirmation of Jukes's observation as regards this bay in two of the rough and very sketchy illustrations of a rare pamphlet entitled "Narrative of a Voyage from Sydney to Torres Straits, in search of the survivors of the 'Charles Eaton'; in His Majesty's Colonial Schooner 'Isabella,' C. M. Lewis, commander," 1836, by W. E. Brockett. In these plates (figs. 26, 27) two headlands are shown to the cove, which are distinctly stratified, and, even in this coarse figure, bear a distinct resemblance to the volcanic ash of the Murray Islands, more particularly, perhaps, that of Waier. The Rev. A. W. Murray, in his "Forty Years' Mission Work in Polynesia and New Guinea," 1876, says, "Huge boulders lie scattered all round the coast, and in some parts there are great piles of sandstone" (p. 447).

We have nothing to add to the little Jukes says about the distribution of the reefs round and around Ĕrub. From the Admiralty Chart it appears that the reef is practically absent on the western side of the island, but it extends continuously to a distance of four miles to the north-east. Beyond this, again, is a very large continuous reef which has a general trend a little east of N.

A thin section of the lava of Ĕrub shows the rock to be a brilliantly fresh olivine-basalt, with a fluidal groundmass mainly occupied by plagioclase microlites and augite granules. The porphyritic augites are greatly penetrated by the original glass, and the olivines have also suffered. "Glomeroporphyritic"* aggregates of these two constituents form a marked feature (Pl. xxv., fig. 3), and the absence of the plagioclase from these groupings would lead one to conclude that the felspar was the last to separate from the matrix. Had the crystallizing process here revealed to us gone on, without the interruption caused by the removal of the fluid-mass to the surface of the earth, an augite-peridotite would have been produced, a mother-liquor being left behind capable of producing little else than plagioclase.

*Judd, "Tertiary Gabbros in Scotland and Ireland."—Quart. Journ. Geol. Soc. London, vol. xlii., p. 71.

Ĕdugor, Zăpker, and Uga.

Five and a half miles due west of Ĕrub is the islet called Ĕdugor* (Nepean Island). Nothing is known as to its geology, but it is probably a mass of basalt. Zăpker† (Campbell Island) lies fourteen and a-half miles west of Ĕrub. It is a small island about half a mile long. We are also ignorant of the constituent rock of this island. The Admiralty Chart states "tops of trees 105 feet," in which case the land of the island must be about 50 feet in height at the least. This proves that it cannot be a coral islet, and consequently there is presumptive evidence that it is also basaltic.

Uga (Stephen's Island) lies four miles to the north-east of Zăpker; it is very slightly larger than the latter. Uga is an ellipsoidal mass of basalt, rising very steeply, and in most places precipitously, from the shore. The top is an undulating plateau from 50 to 100 feet above sea-level and is covered with a rich volcanic soil which supports an extremely luxuriant vegetation. It is, in fact, one large garden.

The three last-mentioned islands are surrounded by very wide fringing reefs. That surrounding Uga is especially broad, except to the north, where it is comparatively narrow; so far does this reef extend to the south, that a channel only three-quarters of a mile wide separates it from the reef of Zăpker. There are two or three uncharted small independent coral reefs to the south-east of Zăpker and Uga.

In Uga, the lava is a scoriaceous basalt, but is distinct from those previously described, in that it contains conspicuous porphyritic felspars. Its dull grey aspect, resembling some of Gümbel's "leucophyres," scarcely prepares one for the freshness of the plagioclase when viewed under the

* "Attagoy" of the Chart, perhaps more correctly Ătăgor. Jukes (vol. ii., p. 311) has by some error interchanged the names of Nepean Island and Stephen's Island, the former he calls Oogar (Hoogar in his map, vol. i.), and the latter Attăgor.

† "Tappoear" of the Chart, probably a misprint for Tăpoga. (The name adopted in the text is that given by Macgillivray, vol. ii., p. 43.)

microscope. But the porphyritic olivines are strongly edged with orange-brown decomposition-products, which penetrate the crystals along planes of schillerization parallel to the brachypinacoid, emphasizing the rarely seen cleavage planes parallel to both the pinacoids (Pl. xxv., fig. 1). Augite is present, mainly as granules in the groundmass. The rock must be described as an olivine-basalt; but it has little resemblance to the more glassy types at Mer.

Similar, but more decomposed, rocks occur as pebbles in the conglomerate which forms irregular masses on the shore. Rolled fragments of earlier limestones, with fan-like and fibrous crystallization, appear in the groundmass of the conglomerate, together with the usual remains of nullipores, foraminifera, spines of echinoderms, and fragments of larger organisms. The cementing material is calcareous, dusky, and almost opaque in section, being full of minute impurities, such as clay worn from the decomposing lavas; and the rock is clearly a water-worn sediment, and not a calcareous volcanic tuff.

Măsaramker.

About twenty seven miles north of Ĕrub "another patch of igneous rock shows itself in the centre of a small reef, called by us Bramble Key; but the native name is Caedha [Keda].* This is a mass of rock twenty or thirty feet high, and about twenty yards across, in the centre of a coral reef, which has a sand-key at one end of it. Another small patch of the same rock is seen three-quarters of a mile distant to the S.E., dry only at low water. This rock has a singular appearance, being a dark-red cellular lava, the cells of which are filled by a white earthy mineral in a pulverulent state (Jukes, vol. i., p. 207). "I have already mentioned the volcanic rocks which jut up in the middle of this reef. The reef itself is almost entirely composed, as to its surface, of one coral, *Pocillopora* [*Heliopora*] *cærulea*, of a greyish colour outside, but a beautiful blue when broken open. It

* The Admiralty Chart calls this islet Massaramcoer. We have endeavoured to present this word more phonetically.

occurred in large, flat, stool-like masses, with indented edges, often as much as one or two yards in diameter. I never saw it elsewhere, except as small detached blocks of coral, in the hollows and holes of a reef. The sand-key on one side of the reef was precisely similar in appearance and structure to Raine's Islet, except that it was much smaller. It equally abounded with 'spinach' and bird's eggs'' (*l.c.* p. 218). The specimen (No. 266) collected by Prof. Jukes is a grey, vesicular, basaltic andesite.

IV.—The Central Coral Islets.

Our central division of Torres Straits, it will be remembred, is conventionally limited by the two meridians of east longitude, 142° 48′ and 143° 29′. The chief features of this district are the very extensive Warrior Reefs and numerous small detached reefs, many of which are capped by sandy islets.

The Warrior Reefs may be divided into two groups, the northerly and the southerly. The former runs north and south, and is approximately bisected by the line of longitude 143° 10′. It commences in lat. 9° 12½′ or five miles from the coast of New Guinea, and extends to lat. 9° 34½′. It thus has a length of twenty miles, and has an average breadth of seven miles, widening in places to 10 or more miles (nautical). A passage has recently been discovered in lat. 9° 21′, which will prove very useful for vessels passing between Ĕrub and Saibai.

The southern division of the Warrior Reefs runs north-east to south-west, and is separated by Moon Pass, which is a dangerous passage. It is nearly nineteen miles long and averages three in width. Its northerly extremity lies just to the west of long. 143° 10′. The triangular south-western end is cut off by a narrow curved passage, Canal Mauvais, and it is on this that Tud or Warrior Island is situated.

Tud.

Tud is a small island, less than a mile long, and about a quarter of a mile wide. It is surrounded on most sides by a fairly wide reef, which is

separated by a narrow channel from the south-western extremity of the long and extensive Warrior Reefs.

Tud is merely a sand-bank heaped up by the sea and wind; probably it is nowhere more than twelve or fifteen feet in height. The whole surface of the interior of the island is covered with rolled pebbles of pumice. The largest piece of pumice known from this island measures 343 mm. × 228 mm. × 305 mm., and weighs 8·42 kilograms. It is carved into a rude resemblance to a human face, and was used in sorcery; it is now in the British Museum. The interior of the island is flat, and supports a vegetation of bushes and herbage; in one spot only, which is about one-third from the northern end, are there a few trees. It was here that the sacred ceremonies used to take place. There are only a few small cocoanut palms. The single water-hole contains brackish water.

At the northern end of the island a sand-spit projects, which appears to be increasing in size. At the south-east corner is a large bay or lagoon, which is filled with water only at the highest tides during the south-east monsoon, but it is said to be constantly full during the north-west monsoon. The shore on the eastern side has a gentle slope of 7° to 10°; but that on the south and western aspect is in most places so cut by the sea that it presents small cliffs three or four feet in height, flanked towards the sea by a sand-beach. On the eastern side there is a furrow in the sand concentric with the coast and immediately behind the ridge of sand formed by the highest tides. Towards the southern end of the eastern side a second furrow makes its appearance on the seaward side of the first; it begins by being small, and the first is relatively very broad; then both furrows come to have approximately the same size. Round the lagoon there are also concentric ridges of sand; and the lagoon itself is silting up in such a manner as to produce low ridges and shallow concentric hollows.

Patches of shelving beach rock, composed of blown sand and *débris*, are found on the north-western and south-eastern aspects; the longitudinal lines of the former run at right angles to north-west or west-north-west, whereas those of the latter are at right angles to east-south-east. The average angle of inclination is from 7° to 15°.

We may conclude that the island was formed by the combined action of the waves and the south-east trade-wind, and that it is still extending in a northerly, easterly, and south-easterly direction; but that it is slowly being washed away along its western and southern shores.

Giaka, Săsi, Măsig, and Umaga.

To the south and south-west of Tud lie the Dungeness Reefs. To the north and the south-west, respectively, of these large reefs are the low islands of Giaka (Dungeness Island), and Săsi (Long Island). Although these islands are relatively very large (Giaka is $2\frac{3}{4}$ miles by $1\frac{1}{4}$ mile, nautical, and Săsi $3\frac{1}{2}$ miles by about $\frac{3}{4}$ mile), they are uninhabited owing to their swampy character.

If a line be drawn from Bramble Cay past Damut on its north-east side, and cutting Dungeness Reef, and another from the north-west point of Ĕrub, and past the south end of Aurid, a band fifteen miles broad, and running north-east to south-west, will be formed, which will be found to include nearly all the small islands of the central division of the Straits. South of this band are numerous undefined reefs.

The islands vary in size, from small, bare, nameless sand-banks, to Măsig (Yorke Island), which is about a mile and a-third long by a-third of a mile in breadth. Three and a-half miles north of the latter is the island of Umaga (Keat's Island), which is thus described by Jukes (vol. i., p. 158): "This was a flat island, about a-third of a mile long, with an extensive coral reef on its eastern side. Piercing through the little belt of dense scrub which intervened between the beach and the wood, we got among a grove of lofty forest trees, with spreading boughs and leafy branches, affording a most agreeable shade. This wood formed a striking contrast to the hot, dry, shadeless gum-tree forests of Australia. A great number of white pigeons [*Carpophaga luctuosa*] had bred in these trees."

V.—The Western Islands and their Relation to the Queensland Axis.

Our account of the geology of these islands is so meagre that we feel some apology is needed; only a few specimens of the rocks were collected as it was evident that the elucidation of the geological history of the larger islands would take a considerable time, and it was work which should be undertaken systematically by the Queensland Government.* As gold has been found in small quantities in Hammond Island, we suppose these islands will in due time be studied by State experts.

We may, for the sake of convenience, divide the islands of the Western Division into the following groups:—1, the large islands to the westward; 2, the scattered high islands; 3, the delta islands of New Guinea.

1. *The Large Islands.*

West of the longitude 124° 26′ and south of the latitude 9° 55′ are two groups of large islands. These may be termed the Prince of Wales group and the Banks group, from the largest island in each of them respectively.

The Prince of Wales group consists of the following islands, besides numerous others which are unimportant:—Muralŭg (Prince of Wales Island), Nărupai (Horn Island), Maurŭra (Wednesday Island), Waibĕn (Thursday Island), Gialŭg (Friday Island), Pălilŭg (Goode Island), and Keriri (Hammond Island).

Muralŭg.

Muralŭg, or Morĭlŭg, the largest island in Torres Straits, is situated fifteen miles due west from Cape York. It is irregularly quadrangular in

* Mr. A. Gibb Maitland, in his report to the Queensland Government, entitled "Geological Observations in British New Guinea in 1891," states (p. 17) that Dauar was the only island of Torres Straits of which he had any personal knowledge; and these islands are not included in Messrs. Jack and Etheridge's important work on the "Geology and Palæontology of Queensland and New Guinea," 1892.

outline; the longest diagonal, *i. e.* from Heath Point to Cape Cornwall, runs approximately from north to south, and is nearly eleven nautical miles in length. The island is extremely hilly, the hills rising up more or less directly from the shore, except in the north-east corner, where there is a flat mangrove swamp, over two miles long and half a mile or so broad. The interior of the island is entirely hilly; the highest of the hills is only 761 feet in height, and all of them are covered with trees. There is one north and south valley, extending from the mangrove swamp to Port Lihou, which forms a natural highway across the island.

The physical features of the other islands of this group are similar to those of Muralŭg. Most of them are surrounded by a fringing reef.

Waiwir.

Waiwir is a rocky islet surrounded by a small reef, and situated between Friday, Goode, and Hammond Islands.

The rocks collected on Waiwir are derived from the destruction of the eurites and granites that are so common in these islands. The coarse grains of quartz and felspar are at times slightly waterworn; but some of the grains of quartz retain their crystalline faces, as if broken freshly from a eurite or quartz-porphyry. These massive grit-like rocks evidently accumulated at an early period; probably the eurites were broken up during some phase of the more ancient series of eruptions, Waiwir being formed of the tuffs of that period, just as the Murray Islands have been formed from more basic materials in far more recent geological times.

Deadman's Island.

Deadman's Island is a tiny patch of rock, on the northern point of the fringing reef of Thursday Island. It is covered with scrub, and receives its name from the fact that it was formerly used as a cemetery by the natives.

This islet bears record of ancient eruptions, like so many of the islands of the straits. The dark-grey compact lava proves to be a much altered

quartz-andesite, approaching rhyolite, with biotite as its ferro-magnesian constituent. The outline of many of the dark altered porphyritic constituents suggests that hornblende may also have been present; but there has been such extensive decomposition and reconstruction within the shells of the crystals that even the biotite is difficult of recognition. This type of alteration resembles that due to the action of the hot lava-magma as exerted in the case of the hornblendes of Auvergne and other places. The ground mass now resembles that of the mica-aphanite of Năgir; but secondary devitrification has probably gone on to a very great extent.

The Banks Group consists of Moa (Banks Island), Badu (Mulgrave Island), Mabuiag (Jervis Island), and a large number of smaller islands, the largest and most southerly of which, Wara (Hawkesbury Island), lies half way between Bădŭ and Pălilŭg. Fringing reefs more or less surround the majority of these islands.

Between Moa and the Prince of Wales group are five long and comparatively narrow reefs, which run east and west, besides isolated patches.

Ormans Reef.

North of the Banks Group lies the vast, unmapped Ormans Reef. The Admiralty Chart states:—"The coast of New Guinea is about 36 miles north of Jervis Island, but there is no known passage between."

The channels in that portion of Ormans Reef which is close to Mabuiag have sloping sides, which are clothed with Zostera and Alcyonarians. On the windward, or south-east, aspect of the reefs, where the currents sweep past, the sides of the reefs are vertical and covered with Madreporaria, and there is no Zostera. On the lee side (or north-west), however, the slopes are less steep than to windward, and are covered with Zostera, Sponges, and Alcyonaria, and but few Madreporaria. Large portions of these reefs dry at the lowest tides. The surface of the dried portions is fairly uniform, consisting of a flat plateau of dead coral, which forms a kind of semi-crystalline rock, covered with mud. There are patches of fairly clean sand in many places, and occasionally a lump of

coral stands up above the dead level. Scarcely any living coral was noticed as being exposed by the tide, and that only near the margins, and for but a short time. The projecting bosses of coral are usually a species of Astræa. One specimen formed a flat stool a few inches in height, and six feet by four feet in diameter; this one, like most of those which have reached a certain size, had living coral only at the periphery, the centre forming a shallow, muddy depression. These humps thus constitute a kind of miniature atoll.

Moa.

The island, known on the charts as Banks Island, is situated twenty miles north of Thursday Island and north of the Torres Reefs. It is nearly as large as Muralŭg; the eastern side is very hilly, the highest eminence being 1310 feet in height. This hill, and the district around it, are known by the natives as Moa, the western low-lying portion of the island, including the village on the north shore, being called It. Parts of the island appear to be fairly fertile, and bamboos of large size grow in places.

Mabuiag.

Mabuiag is a small island situated midway in the narrowest part of Torres Straits. It is triangular in outline, each side measuring about a couple of miles. The island is very hilly and only moderately fertile.

Mabuiag, in the compact pale-grey masses of Kwoiam's Hill, offers a fine series of rhyolitic tuffs, full of quartz fragments, and belonging apparently to the most ancient eruptive series of the axis. In these, as in the tuffs of Cader Idris,* included crystals have renewed their growth by withdrawal of material from the fine ash round them. A plagioclase crystal, 5 mm. in length, has thus added a zone to itself, which has become on one side as much as 15 mm. in width. As is

*Cole and Jennings, "On the Northern Slopes of Cader Idris."—Quart. Journ. Geol. Soc., vol. xlv., p. 430.

usual in such cases, the repeated twinning of the original is carried on into the added zone.

A fine-grained red rock from this island, with porphyritic quartz and felspar, proves to be a much altered eurite with micropegmatitic structure. Except for the formation of a more delicate zone round the porphyritic crystals, and the extension of these crystals outward for a short distance in optical continuity with the corresponding constituents of the micropegmatite, the radial structures of the "granophyres" of Rosenbusch are not here represented; and the groundmass is practically a graphic granite on a minute and compact scale. The magnetite patches that prevail in it may represent former biotite, and translucent brown material still occurs in connexion with some of them.

2. *The Scattered High Islands.*

Between Cape York and the opposite coast of New Guinea are numerous small rocky islands, which are the isolated peaks of an ancient ridge of igneous rocks. The more important are, Muri, and the other Mount Adolphus Islands, Năgir (Mount Ernest), Gĕtulai (Pole Island), Suărăgi (Burke Island), Saddle Island Yăm (Turtle-backed Island), Găba (Brothers' Hills), and Dauan (Mount Cornwallis.)

Like all the other rocky islands in the western divisions of the straits, they are somewhat infertile owing to the scarcity of water; but at the same time the hills are covered for the most part with grass, and bushes, and trees. In none of these islands are coco-nut palms plentiful. Some islands possess a grove or two; in others, such as the Prince of Wales group, they were entirely absent until a few were planted by the white men. Bananas, too, are of very local occurrence, and even so are few in number.

Most of these islands are surrounded by a fringing reef, but this eastern band of our western district is almost entirely devoid of detached coral reefs. The chief exception is Mourilyan Reef, which lies just south of Găba. This clear sea has, as Jukes noticed, "a remarkable uniformity of bottom" (vol. i., p. 331) of from eight to eleven fathoms.

Muri and Mukwa.

Jukes says (vol. i., p. 134):—"The York Islands [Mount Adolphus Islands] were exceedingly barren and uninteresting. The rocks are all porphyry, varying from a softish base, apparently feldspathic, with small transparent quartz crystals, to a hard silicious base, with flesh-coloured crystals of felspar. I climbed Mount Adolphus, which is nearly 500 feet high [548 feet], but got only a partial view, owing to the thick stunted wood that clothes its sides, and spreads over the flat plateau of its summit."

On p. 153, Jukes says:—"Cap Island [Mukwa, lat. 9° 50′ S., long. 142° 43′ E.] has been erroneously supposed to be volcanic; it is a bare mass of sienite."

Năgir.

Năgir, situated in lat. 10° 15′ S., long. 142° 29′ E., has, roughly speaking, the form of an equilateral triangle; one apex of the triangle points in a southerly direction, and the north-easterly angle is produced into a small rocky promontory. The southerly portion of the island rises steeply, and culminates in a peak said to be 751 feet in height. On the northern aspect some of the spurs of the hill are cultivated, and there is a moderate amount of level ground at its base, which is well wooded and covered with jungle. Except the really precipitous portions, the whole peak is well wooded. A rather narrow fringing reef surrounds the island; it is broadest towards the north.

The rock weathers into remarkable blocks and pinnacles, the forms assumed in the north-east angle being peculiarly fantastic. The low-lying land on the northern aspect of the island is derived partly from the detritus of the hill and partly from shore-deposits. The northerly shore is a typical coral beach; but at its easterly end, at its junction with the neck of the promontory, there is a variety of shore-rock which does not appear to occur elsewhere in the straits. *In situ* it has the general appearance of an ordinary blown coral-sand rock; but instead of rolled calcareous fragments,

it is composed of grains of quartz and felspar cemented by a compact paste of carbonate of lime. It is, in fact, a calcareous arkose derived from the disintegration of the neighbouring rocks.

Macgillivray says:—"Mount Ernest is little more than a mile in greatest length"; the rocks are "grey sienite, and from the striking similarity of aspect it appeared to me pretty certain" that Pole [Gĕtulai], Burke [Suărăgi] and Banks [Moa] Islands are of the same formation; they agree in exhibiting massive peaks, 409, 490, and 1246 feet in height, respectively (II. p. 35).

Macgillivray refers in the following terms to a coral conglomerate which he regards as proving a local upheaval:—"At one place I saw indications of an upheaval of the north side of the island, in a bed of coral conglomerate six feet thick, with its raised wall-like edge towards the hill as if tilted up, and the remainder sloping down towards the sea. A similar appearance on a small scale exists on most of the coral islands which I have visited, but I had not before seen these sloping beds above the influence of salt water, or at least beyond reach of the spray, still less supporting luxuriant vegetation, consisting in the present instance of a large extent of jungle, with trees often of great size, and a dense growth of underwood." (Narrative of the voyage of H.M.S. "Rattlesnake," ii., 1852, p. 38.)

This formation has all the characters of an ordinary beach-rock, and it still maintains the usual angle of such deposits. There is a face or escarpment which looks away from the sea, as is always the case in these shore deposits; but in this case it is some six feet high, instead of being but a few inches or a foot or so in height, which is all the *visible* height of the usual shore-rock. The cliff-like appearance of this deposit is due to a subsequent washing away of the soil during heavy rains. There is every sign that a considerable amount of water collects and flows past this spot, forming a creek in the north-west monsoon. The soil gradually rises to its normal level on the landward side of the miniature cliff.

FIG. 6.—Diagrammatic sketch through the beach at Năgir, the vertical scale is exaggerated about five times.

The occurrence of this formation at such a distance (about 150 yards) from the sea can be easily accounted for on the supposition that the beach has gradually extended further out on the reef in an ordinary manner, and that it merely marks an older coast-line. The upper surface of the sandy conglomerate does not rise to a greater height than that of the beach, which is now covered with the jungle. If this formation proves elevation the movement can have taken place for only a few feet in height, and it must have been extremely local in extent. It is the sole spot in the straits for which any case for elevation can be made out. D'Albertis makes the following remarks about this island:—"The island, if it may be so called, consists of a lofty peak and a sandy plain towards the north, which appears to have emerged from the water at no very distant date. This plain is in constant process of enlargement from the sand thrown up by the sea, while at the same time, the polyps extend the area on which the sand is deposited. The vegetation of the island is rather scanty, although fine trees are not wanting, especially on the beach on the north-side." ("New Guinea: What I did, and What I saw there," vol. ii., 1880, p. 4).

The singular and interesting calcareous arkose of Năgir shows in section under the microscope a dense brown ground, in which large grains of quartz and felspar are embedded. The latter have evidently been derived from the decay of the granitic rocks; and the felspars often show the microcline-structure which is also a marked feature of the granite of the island. Some rolling of the materials has occurred prior to the consolidation of the cement. This cement, which separates the grains clearly from one another (Pl. xxv., fig. 2), consists of a minutely granular brown material, thickly set with fragments of foraminifera, calcareous algæ, spherasters of ascidians, prisms from molluscan shells, and minute chips of quartz and felspar.

The granite of Năgir shows the tendency towards a simultaneous development of quartz and felspar that is common in the western islands of the straits. Biotite is present, but in small proportion, so that sections of the rock resemble aplite. The approach to graphic granite is further emphasized by the presence of a felspar with marked microcline-structure, in addition to repeatedly twinned oligoclase.

Far more basic igneous rocks occur, however, in this island. There is a light grey diabase with translucent felspars, which weathers into spheroidal shells of a rusty brown colour. Under the microscope the porphyritic plagioclases are seen to be remarkably little altered, though the biotite, which is abundant in the groundmass, has mostly become replaced by chlorite and yellow epidote. The rock was originally an augite-biotite aphanite, biotite greatly predominating over pyroxene. The porphyritic felspars, judged by their extinction-angles, are Labradorite.

A more finely grained and darker rock of the same character occurs, looking almost like a basalt. It must, indeed, be classed as a mica-aphanite or "mica-trap," the biotite in this case being disseminated very abundantly as minute crystals in the groundmass, and there playing the part of the granular pyroxenes of basaltic andesites and basalts. The possible relation of these altered igneous rocks to those of Queensland will be touched on in the description of Dauan.

Saddle Island.

Saddle Island, 12 miles N.E. by E. from Năgir (lat. 10° 10′, long. 142° 41′), is a small island with two hills of a rounded contour, which therefore afford a contrast to the peaked hills so characteristic of most of the neighbouring islands. The northern hill is precipitous on its northern face, and with a steep grass-covered slope to the south. The southern hill is 180 feet in height; between the two hills is a low, flat isthmus, which possesses all the characters of a typical coral island: in other words, it is merely a beach, with the usual pumice pebbles, and supporting a small amount of scrub. There was here what appeared to be a large deserted nest of the mound-bird (Megapodius).

To the E.N.E. a tongue-shaped projection of coral-sand beach-rock is being formed on the reef; and to the N.W. there is a large, flat, low, sandy promontory, along which runs a sand-dune in a W.N.W.–E.S.E. direction. Its height must be from 30–40 feet; it is covered with tufts of coarse grass. On the top are friable slabs of slightly consolidated sand. There is a second smaller mound parallel to the first towards its south-easterly corner.

On the north beach there is a beach-rock, composed mainly of worn blocks of coral and numerous coral fragments firmly cemented together. There is a great amount of worn coral fragments all along the beach.

On Saddle Island there are grey, fine-grained tuffs, resembling sandstones, which show in section abundant irregular fragments of quartz. These are only rarely corroded by the matrix in which they originally lay; most of them are extremely angular or irregularly conchoidal in fracture. Orthoclase crystals occur, which have often been broken and re-cemented in the tuff. Repeatedly twinned examples of albite are present, showing in some cases lamellæ bent by pressure. Devitrified glass is included in some of the felspars. Pumice does not seem to occur, unless the minute particles of the groundmass of the tuff are derived from its complete comminution. The rock is such as would be formed by the shattering of a porphyritic eurite or rhyolite. It is thus a highly silicious volcanic ash, and is nowhere so coarse as the more easily determined rocks of Mabuiag, which are probably of the same geological age.

Dauan.

Dauan (or Tauan) is a small, very hilly island, seventy-five miles due north of Cape York, six and three-quarter miles from Daudai, as the neighbouring coast of New Guinea is called, and three and a-quarter miles from Saibai. It is somewhat triangular in outline, each side being about two miles in length. There are several hills, the highest of which, Mount Cornwallis, is 795 feet in height. Owing to the weathering of the granitic rocks, the hills have a very rugged appearance, the rocks being much fissured, and looking as if boulders had been fantastically heaped one upon another. The island is consequently but moderately fertile. Mr. Maitland's* description practically coincides with our own.

D'Albertis says:—"The island is hilly, and three or four of the peaks are from five to six hundred feet high." He was "astonished at the sight of the colossal masses of granite of which it is formed. In the interstices there is neither earth nor sand. I descended for more than thirty feet into

* "Geol. Observations in British New Guinea in 1891," p. 17.

one of the caves without reaching the bottom. . . . The higher I climbed the hill the larger were the blocks of stone."* He gives an illustration of the island in vol. ii., p. 208.

While Dauan may be considered as a part of the edge of the continental plateau, and a northern representative of the ancient Queensland axis, it owes its materials to igneous action equally with the recently formed islands to the east. The granitic rocks examined show signs of micropegmatitic intergrowth of orthoclase and quartz. One of them is a biotite-granite, with a prevailing granular structure; muscovite has arisen only as a feeble secondary product; and the biotites contain small zircons, as is so often the case in granites. Plagioclase, referable to oligoclase, as judged by its extinctions, is fairly abundant. A second specimen is a hornblende granite, in which micropegmatitic structure is generally but poorly developed; the orthoclase shows a streaky perthite structure; and plagioclase is present, but is decidedly subordinate. The hornblende is a brown-green variety, and brown biotite occurs freely. Magnetite has separated out in crystalline groups and patches, and the general facies of the rock would be that of a quartz-diorite were not orthoclase predominant. Small crystals of sphene occur sparsely; but apatite is common, embedded in the quartz or in the felspar.

Another rock collected in Dauan is of a more volcanic type, being a much altered biotite-aphanite or "diabase," greatly resembling the dioritic "lamprophyres" of the Vosges, or some of the British "mica-traps." Mr. Maitland† mentions a "very fine-grained, steel-grey rock, containing hornblende," which probably forms part of the same series. It is, indeed, probable that Dauan contains records of various ancient eruptions, which may have taken place after the consolidation of the granites, or during the movements that brought them towards the surface. Sir R. Daintree‡ held that the hornblende-granites, so common in Queensland, were all to be referred to the pre-Devonian metamorphic series. They are, indeed, quartz-diorites rather than granites; but typical granites,

* "New Guinea—What I did, and What I saw there," 1880, vol. i., p. 234.

† "Geol. Observations in British New Guinea in 1891," p. 17.

‡ "Geology of Queensland," Quart. Journ. Geol. Soc., vol. xxviii. (1872), p. 300.

passing into quartz-porphyries,* form a great part of the north-eastern coast of the colony from Cape York to Broad Sound. These, however, appear to be also pre-Devonian. Various eruptions occurred in Carboniferous† times, giving rise to tuff-beds and to the dykes associated with the quartz-veins of certain of the Queensland gold-fields, the Gympie area, for example; and at two comparatively recent periods, suggested by Sir R. Daintree as Miocene and Pliocene, volcanic rocks have been poured out in Northern Queensland. The general alliance between the rocks of the western islands of Torres Straits and those of the fundamental floor of Queensland, and the long-suspected‡ continuation, since verified, of the Cape York axis into New Guinea, make it reasonable to suppose that we have in the rocks of Dauan contemporaneous representatives of those of Queensland. In view of this, the discovery of ancient tuffs and lava-flows in other islands to the south, such as Mabuiag and Deadman's Island, may indicate that the uplifting of the continent prior to Carboniferous times was accompanied by volcanic manifestations such as occur on its edge at the present day.§ This contention is strengthened by the fact that in the Cockburn Islands, off the east coast of the Cape York Peninsula, compact dark "felstones" occur, with a marked fluidal structure upon weathered surfaces. The flinty aspect of these rocks suggests that they may have been affected by contact-metamorphism; but they retain all the characters of highly silicious lava-flows, originally either rhyolites or quartz-andesites. In their movements some of the bands have been broken up, and their fragments have become eutaxitically included in the fluidal groundmass. Traces of spherulitic structure remain in the devitrified matrix; and the compact rock, as a whole, reminds one of the "felstones" or altered rhyolites of Wales. (Pl. xxv., fig. 7.)

* "Geology of Queensland," Quart. Journ. Geol. Soc., vol. xxviii. (1872), p. 302.

† Jack and Etheridge, "Geology and Palæontology of Queensland and New Guinea," pp. 72, 79, 146, and 150, and pls. 48, 51, 52, and 53.

‡ See Rattray, "Geology of the Cape York Peninsula," Quart. Journ. Geol. Soc., vol. xxv. (1869), p. 298.

§ See Reclus, "Nouvelle Géographie universelle," t. xiv., p. 729.

Mabudauan Hill.

Although Mabudauan Hill (Mabudaui Hill of the Charts) is on the mainland of New Guinea, we feel justified in alluding to it, as it is clearly part of the Queensland axis. So far as is known it is the only hill in this part of New Guinea, and it may justly be regarded as the most northerly of the scattered rocky islets of the straits, and one which has been physically annexed to New Guinea by the encroachment of the delta-system of the Fly River.

In the "Rough Sketch" map which is an "Enclosure in Despatch No. 18, of 19th March, 1890," and is published in the "Annual Report on New Guinea, July, 1890, to 1891," we find that Mabudauan Hill is 150 feet in height, and is situated on the western bank at the mouth of the Pahoturi River (Kawakussa River), opposite the island of Saibai. Its position lies fifteen miles north-east of Dauan, in lat. 9° 17′ S., long. 142° 44′ E.

In his despatch Sir William Mac Gregor says:—"The hill is nearly two hundred feet high [192 in the Admiralty Charts], granitic, covered by large trees, and has some clumps of old coco-nut trees, fresh water, and some amount of fair planting land."

Owing to the kindness of Mr. A. Gibb Maitland, of the Geological Survey of Queensland, we have received a specimen from this mass, which is a true granite, like those of the islands of the Queensland axis. In Mr. Maitland's report,* which embodies an admirable series of observations on an area hitherto but little visited, Mabudauan (Mabaduan) is described as consisting entirely of granite; and a microscopic examination of the rock is quoted from Mr. W. H. Rands, showing the presence of biotite and oligoclase.

3. *The Delta Islands of New Guinea.*

Under this heading we class Kawa, and the other islands at the mouth of the Wăsi Kŭsa River, Boigu (Talbot Island), Saibai, and the adjacent islets, and further to the east, Yaru, Bobo (Bristow Island), and

* Geol. Obs. in Brit. New Guinea, p. 16.

Parama (Bampton Island), which lies in lat. 9°, long. 143° 20′, by the mouth of the Fly River.

All these islands are low-lying and swampy, and wooded chiefly by mangroves. Many are uninhabited.

Geographically they may be considered as outliers of New Guinea. They owe their existence to the detrital matter brought down by the Papuan rivers, which, settling down, forms first shoals, then banks, which in time bare at low tides; and later, owing to mangroves gaining a foothold on them, they form mangrove swamps. At a later time, as more ground is reclaimed, a flora makes its appearance that is more suited to the drier conditions.

Saibai.

Saibai is one of the largest islands in the straits. It is, roughly speaking, ellipsoidal in contour, with a maximum length of $14\frac{1}{2}$ miles, and a breadth of $5\frac{1}{2}$ miles. The island is low, mainly consisting of a large swamp surrounded by a narrow sand-beach. The channel between Saibai and Daudai (the neighbouring coast of New Guinea) is two and a quarter miles wide at its narrowest part. The small island (Sobareige) to the north of Saibai is practically part of it, as it is separated from the latter by only a very narrow channel.

The following are a few notes of some islands off the coast of North Queensland:—

Boydong Cays.

Boydong Cays are low sand-banks about ten miles from the Queensland coast, in latitude 11° 30′ S.

The smaller island is surrounded by a low bank, and towards the west there are a few trees; the centre of the islet is a flat plain, covered with coarse grass.

The large island is similar to the foregoing, except that bushes and

trees occupy the whole island. At the north-west corner, and along the south-west, there is a sandy beach; the rest of the foreshore is coral rock. The fringing reef extends to about sixty to seventy yards from the shore at the north and north-west of the island; the edge bares at low water, and shows an imperfect ridge of irregular blocks thrown up by storms.

Cockburn Islands.

The Cockburn Islands are simple conical islands not more than two or three hundred feet in height, which lie some eight miles N. E. of Cape Grenville, in about lat. 11° 59′ S.

The samples of rock obtained from the south island have been described above in connexion with Dauan.

The low sandy islet near by is long and narrow, and only just raised above sea-level. It is covered with pumice and trailing plants, and at the west-end there are a few shrubs. On the north and south beaches there is coral rock.

VI.—General Conclusions.

If we cast a glance backwards over the results of this inquiry, we shall recognise, as one of the facts of most general interest, the now demonstrated extension of the Queensland axis northwards across Torres Straits into New Guinea, through the islands of Năgir, Saddle Island, Mabuiag, and Dauan, into Mabudauan Hill of the Fly River delta. The ancient plicated range of mountains bordering the east of Australia, and well named * the Australian Cordillera, can now be traced through over 35° of latitude from Tasmania in the south to New Guinea in the north, where its relations to the Owen Stanley range of that island have yet to be determined.

The Murray Islands, Uga and Ĕrub, by the recent nature of their volcanic rocks, all of a basic type, belong to a line of later movements, and may be regarded as pertaining to that great system of still progressing

* Suess, "Das Antlitz der Erde," Bd. ii., p. 188.

folds which are included in the Pacific * "zone of fire." They lie on the extremity of the submerged ridge which continues the direction of the North Island of New Zealand through Norfolk Island, the Avon Islands, and other scattered islets of the Coral Sea, and which forms the western boundary of Carpenter's Deep. New Caledonia, which Suess includes in this axis, appears rather to form a parallel member adjoining it on the north, but partly separated from it by the depression known as the "Gazelle" Deep, which is apparently a negative fold correlated with the positive folds of the parallel New Caledonian and Norfolk Island systems.

Attention may be drawn to the important structural features which follow a line drawn from Chatham Islands, on the east of New Zealand, to Port Danger, on the Australian coast. The trend of this line is parallel to that of the Gazelle Deep and the Norfolk Island ridge; it traverses the fracture which separates the north and south islands of New Zealand, is continued along the ridge which bears Lord Howe Island (once of much greater extent) near its extremity, and ends at the broken knee of the Australian Cordillera, where Cretaceous rocks pass from the interior of the continent across the mountains to the coast. Closely adjacent is an abyss, separated, by the extension of the Lord Howe ridge, from Thomson Deep on the south. This abyss might fairly be termed Jukes Deep.

Up to the present the labours of explorers have afforded only glimpses into the structure of New Guinea; but these are very suggestive. Macgillivray, a traveller of true scientific insight, remarked more than forty years ago, that the Louisiade Islands consist of mica slate, having the same strike as the trend of the archipelago, a statement confirmed by

* It is important to notice that the later phases of volcanic activity still continue in the D'Entrecasteaux group, at the south-east end of New Guinea. Thus Mr. Maitland ("Geological Observations in British New Guinea," pp. 23 and 24) observed numerous hot springs, solfataras, and fumaroles on Moratau; while on the little island of Doleu steam was found issuing from fissures in the coast, and sulphur was in course of deposition.

Vulcan Island (long. 145° E.), on the north of New Guinea, was active when Dampier passed in 1700. D'Entrecasteaux found it fuming in 1793; but in D'Urville's time, 1827, it was extinct (Coutts Trotter, "New Guinea," Proc. Roy. Geogr. Soc., new ser., vol. vi., 1884, p. 196).

the recent observations of Mr. Maitland, the latest investigator of this group, who has also shown that the D'Entrecasteaux group similarly consists chiefly of slate and schist, which in Duan strike E. N. E., and thus likewise run parallel to the axis of the archipelago.

The Owen Stanley range, as far south as Mount Suckling, also consists largely of slates and schists, recalling those of the Australian Cordillera. Their strike, unfortunately, is not known. Between Phillip's Harbour and Mount Suckling Mr. Maitland found ancient quartzite of the so-called metamorphic series lying almost horizontally.

Since, however, the D'Entrecasteaux group and the Louisiades can only be regarded as the submerged termination of the eastern end of New Guinea, it would seem that the E. N. E. strike so characteristic for them is more likely than not to be continued into the main island, and so along the Owen Stanley range. If so, the northerly-striking northern end of the Australian Cordillera probably meets a prolongation of the Owen Stanley range at a large angle, the meeting place being a knot, whence radiate mountain chains to the W. N. W. (C. Lotus and Gautier mountains), to the S. (Australian Cordillera), and to the E. S. E. (Finisterre and Owen Stanley range), the E. S. E. range branching into the New Britain Isles and the Louisiades. Such an arrangement would suggest comparison with the structure of Borneo and Celebes.

It is interesting to observe how closely the conditions in this area repeat those which obtained in central and southern Europe during Triassic times. The Australian Cordillera well represents the ancient mountain chain, whose fragments persist as the "horsts" of the Hyères Peninsula, Auvergne, the Vosges, Schwarzwald, Bohemia, the Sudetic and Southern Russia, while the reefs of the Coral Sea bring to mind the dolomite mountains of the Tyrol and other districts in the Alps. The line of contrary flexure, to which the coral reefs stand in a connexion no less close than that of effect to cause, is marked both in ancient Europe and modern Australia by volcanic activity, and in both cases we find the organic *débris* from the reefs commingled with detrital igneous products. We have already described rocks consisting of coral sand and volcanic minerals, and have alluded to the deposits of ash and flows of lava which rest upon and

wrap round the islands of the straits. If we desire to gain some idea of the existing arrangement of the rock masses in the straits, and of their probable destiny, it is to the Tyrol we must turn, where we may interpret the present and prognosticate the future from the records of the past. Here in the marvellous sections of the Ross Zähne and Grüner Bühels we find the remains of coral reefs with overlapping deposits containing rolled pebbles of augite-porphyry, tuff, and blocks of wave-torn coral piled together in admirable confusion, while far above them tower the fantastic peaks of the Schlern and Rosengarten, the remains of ancient coral islands, which now form not the foundations, but the finials of the land. Wandering down the beautiful valley of the Duron, on the right bank, similar relations of coral island and volcano meet the eye, and tuffs and lavas repose on the flanks of a buried reef. The association of coral rocks and volcanic products is indeed an ancient one, for at Portrain, only a few miles from Dublin, we encounter volcanic rocks, adjacent to a coral reef (though not an atoll) of Ordovician age. In the detrital limestone worn from this, we find broken crystals of felspar, and in the adjacent volcanic tuffs rolled fragments of coral limestone. We have already hinted that in the famous Tiree marble an example may occur of the same association even more ancient still.

To the student of the islands surrounding the eastern Australian seas nothing can be more impressive than the number and variety of the rock systems which are beginning to be discovered in them, unless it be the great and wide-spread unconformities by which these systems are separated from each other. We have evidently to do, not with mere volcanic accretions, rising for the first time above the sea-level, but with the fragments of a sunken land, to which belongs a lengthy and eventful history, marked by many ups and downs, land exchanging places with the sea, and sea with land, not once only, but many times. The last great movement seems to have been one chiefly of depression, from which the islands, for the greater part, are only now, or only recently, recovering. Thus, as regards New Guinea,* numerous proofs of recent elevation are to

* Darwin, "Coral Reefs," 2nd edition (1874), p. 177, cites a statement of Lesson ("Voyage de la 'Coquille'") that, near Port Dory, on the north coast of New Guinea, the

be observed on the northern side; and the latest observer, Mr. Maitland,* describes the remains of raised coral reefs as extending from a few feet above the sea-level to a height of two thousand feet. At several points on the southern coast, also, evidence of comparatively recent elevation has been obtained.

Thus Stone † describes a limestone at Anuapata, which contains shells like those in existing seas, and which extends to a height of six hundred feet above sea-level; while Macleay ‡ brought home fossils from Yule Island, which Wilkinson § assigned to the Lower Miocene, and Tenison-Woods ‖ to the Lower Pliocene stage.

In New Britain and New Ireland a soft, white limestone is known to occur, which has been described by Professor Liversidge ¶ as chalk, but which Brady** shows to consist largely of existing species of foraminifera, such as are now to be found in globigerina-ooze, dredged in from 1500 to 2500 fathoms in the South Pacific.

The Solomon Islands, partly constituted of ancient slates and quartzites,††

shores are flanked to the height of one hundred and fifty feet by madreporic strata of a modern date.

Miklouho-Maclay, Proc. Linn. Soc. N. S. Wales, vol. ix. (1885), p. 966.

Martin, K., "Sammlungen des Geologischen Reichsmuseums in Leiden," Bd. i. (1881), p. 65.

Coutts Trotter, "New Guinea: a Summary of our Present Knowledge," Proc. Roy. Geogr. Soc., new ser., vol. vi. (1884), p. 209.

* "Geological Observations in British New Guinea in 1891."

† O. C. Stone, "Description of the Country and Natives of Port Moresby and Neighbourhood, of New Guinea," Proc. Roy. Geogr. Soc., xx., p. 330, and Journ. Roy. Geogr. Soc., xlvi., pp. 34–62 (1876).

‡ William Macleay, "The Voyage of the 'Chevert' to New Guinea," *Nature*, xiii., 1875. p. 153.

§ C. S. Wilkinson, "Notes on a Collection of Geological Specimens, &c.," Proc. Linn. Soc. N. S. Wales, vol. i. (1877), p. 114.

‖ J. E. Tenison-Woods, "On a Tertiary Formation at New Guinea," Proc. Linn. Soc. N. S. Wales, ii. (1878), p. 125.

¶ Prof. Liversidge, "On the Occurrence of Chalk in the New Britain Group," Geol. Mag., 1877, p. 529.

** H. B. Brady, "Supplementary Note on the Foraminifera of the Chalk (?) of the New Britain Group," Geol. Mag., 1877, p. 234.

†† H. B. Guppy, "The Solomon Islands," pp. 11 and 16 (1887).

afford, as is shown by Guppy, abundant evidence of recent and probably still progressing elevation.

Of the New Hebrides and Banks group nearly every island is said by Hosken* to show signs of an upheaval, with which, it is suggested, the absence of barrier reefs may be correlated.

New Caledonia, repeating, as Montrozier† seems first to have pointed out, the structure of Australia in inverse order, is said by Deslongchamps‡ to include a modern Tertiary limestone of recent coral-reef origin, containing shells of living species, while Quaternary coral limestones are described as occurring on the south-west by Garnier.§

To the upward moving peripheral islands the Eastern Australian land stands in marked opposition, an entire absence of marine Tertiary deposits characterising the Cordillera, as Tennison-Woods has insistently pointed out. Cape York and the shores of Torres Straits offer no exception to the rule.

At present the shores of Torres Straits are apparently stationary; certainly they are not rising. The chief author of this Paper has given to the investigation of this subject the pains which its importance would seem to deserve, and is confident that no recent movement of elevation has taken place. This does not preclude the possibility of recent subsidence; subsidence from its nature is difficult to discover; and it may very well have occurred as a concomitant of the upward movements on the north of New Guinea. Upward moving crests must have their downward moving sinuses, and of such a sinus Torres Straits very well may be the shallow end.

If, in a study of the island rim bounding the Australian continent, volcanic phenomena first arrest the attention, further consideration soon relegates

* H. Hosken, "Remarks about the New Hebrides Group," Geol. Mag., ser. 2, vol. viii., p. 82 (1876).

† Montrozier, "Revue Algerienne et Coloniale," Avril, 1860.

‡ E. Deslongchamps, "Documents sur la Géologie de la Nouvelle Calédonie," Bull. Soc. Linnéenne de Normandie, 8me vol. (1862–1863), p. 355.

§ J. Garnier, "Note sur la Géologie de la Nouvelle Calédonie," Bull. Soc. Géol. de Fr. (ii.), xxiv. (1867), p. 438.

these to a subordinate position; not that they are unimportant—probably they are of a vast importance, not yet fully perceived—but they are consequents rather than antecedents in the progress of the movements of the earth's crust, mighty followers in its majestic march. As our knowledge grows, we the more distinctly see in Australia and its islands the ruins of a great southern continent, fractured and submerged, possibly during the great Alpine Himalayan revolutions, and now in process of resurgence, as the vast folds of the earth's crust roll slowly inwards upon the central continental mass.

DESCRIPTION OF PLATES.

PLATE XXII.

MAP OF ISLANDS IN TORRES STRAITS.

PLATE XXIII.

Figur

1. VIEW OF WAIER FROM TEG, THE EASTERN SAND-SPIT OF DAUAR.

   A little to the left of the centre of the picture is seen the sand-spit of Waier, bearing a grove of coco-nut palms.

2. VIEW SHOWING THE LAVA ON THE BEACH AT WEMERPIT.

   This photograph was taken at low tide. At high tide all foreground as far as the sand-beach (Ĕger) would be submerged. The outstanding block of lava is connected by a low ridge with the lava cliff on the right.

   In the distance are seen Waier and Dauar, with its hills, Kĕbĕ- and Au-Dauar.

PLATE XXIV.

Figure

1. View in Mer, taken from near the top of Gelam, and looking about North-east.

   To the left is Gur, the eastern side of the central cone. In the centre is the ridge (Sĕrer) of Mergar, ending to the left in the peak of Pitkir. Between this and Gur can be seen the lava plateau on the other side of Erpat. The lowest slopes of the hill, Dĕbĕmad occupy the extreme right of the picture. Between Gur and Mergar is the valley of Mĕnepat. In the foreground is part of what we call the great crescentic valley, with scattered coco-nut palms.

   A millimetre on the picture above Gur will be seen a very faint line; this is the edge of the reef opposite the village of Las, as shown at low tide. It extends to a spot about 21·5 mm. from the right-hand side of the picture, and about 47 mm. from the top. This spot is the apex of the bend, and below it can be seen the gap due to the influence of the stream which occasionally flows down Erpat.

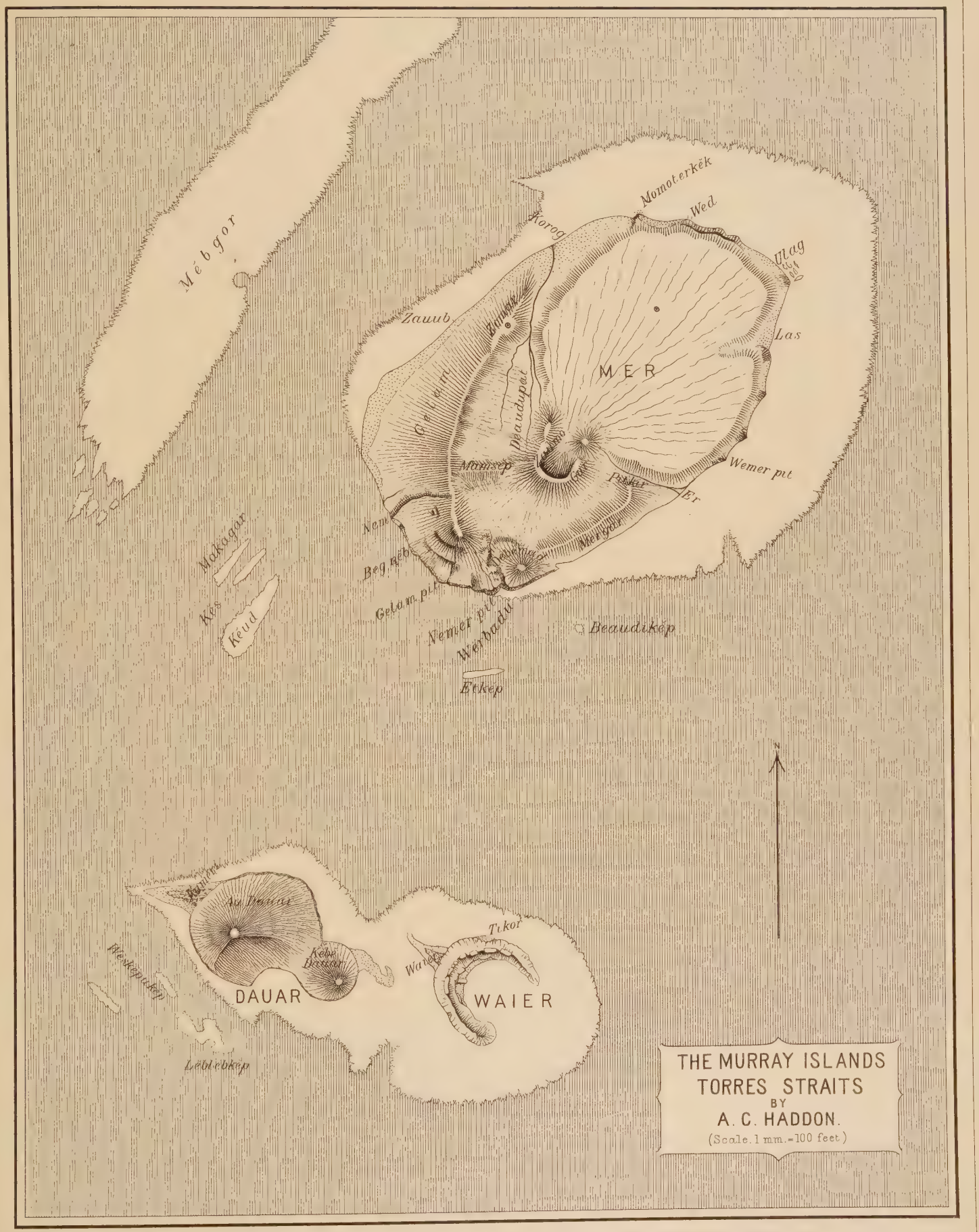
2. View of the Fissured Walls of the Crater, from the Inside, near the highest point of Gelam.

PLATE XXV.

[All the figures are photographed from thin sections, under the microscope, the magnification being about 10 diameters.]

Figure

1. Olivine-Basalt, Uga (p. 448). The olivine is darkened by deep orange products of decomposition, conspicuous on the margins of the crystals. Numerous porphyritic crystals of plagioclase occur, the whole rock being poorer in ferro-magnesian constituents than the typical basalts of the area.
2. Calcareous Arkose, Năgir (p. 460). The dense brown ground, almost opaque in the photograph, is composed of a calcareous cement, which unites grains of quartz and felspar derived from the decay of the granite of the island. The cement contains abundant traces of organisms.
3. Olivine-Basalt, Ĕrub (p. 447). In this exceedingly fresh lava the colourless olivine and pale-brown augite often occur associated in "glomeroporphyritic" groups, the rods of felspar being of later origin and of subordinate importance.
4. Volcanic Ash, gully of Erpart, Mer (434). In the upper part of the photograph is seen one of the pellets of volcanic dust described in the text. The dark scoriaceous particles in the ground of the rock are yellow-brown and brown-green palagonite and glass. Ejected crystals of colourless olivine and brown pyroxene abound.
5. Volcanic Ash, Waier (p. 440). This is formed of highly glassy material. The large fragments are scarcely altered, and consist of pale-brown basalt-glass, with abundant vesicles, and porphyritic crystals of augite and olivine. The minuter material of the groundmass testifies also to the prevalence of glassy olivine-basalt in the volcano of Waier.
6. Calcareous rock, with included silicates, east side of Mer (p. 436). Wave-worn fragments of lava, nullipores, foraminifera, &c., and ejected crystals of augite, olivine, and plagioclase, are cemented together by a deposit of calcium carbonate, the resulting rock being a complex limestone, enclosing silicates that show rounded forms in section. In the lower and in the central and right-hand parts of the photograph, the deposit of calcite which cements the grains together can be well seen. The acicular crystals of which it is composed can be clearly recognised with a higher power, or with the polariscope.
7. Fluidal Rhyolite or Rhyolitic Andesite, Cockburn Islands (pp. 446 and 467). The flow-structure is well seen in the dull flinty ground. The movement has broken up some of the sheets and bands into lenticular fragments. Porphyritic crystals of quartz are visible.



THE MURRAY ISLANDS
TORRES STRAITS
BY
A. C. HADDON.
(Scale. 1 mm. = 100 feet)

Edwin Wilson, Cambridge.

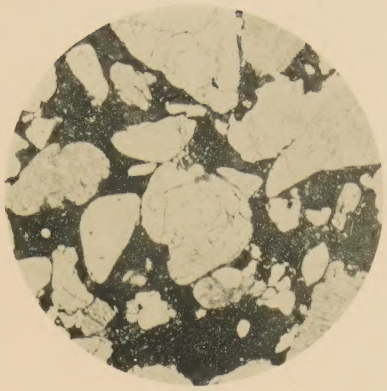
1

2

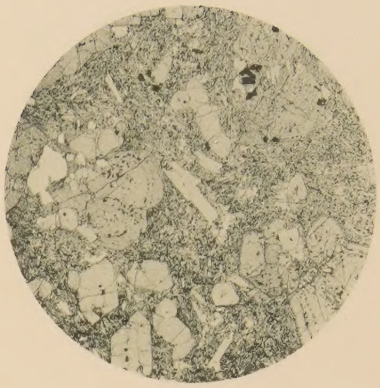
1

2

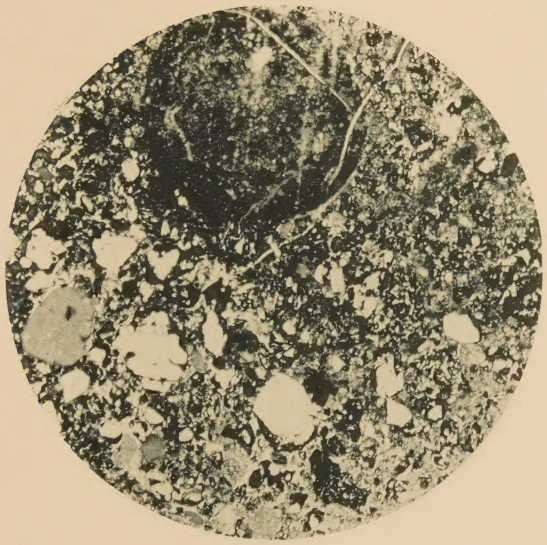
1.



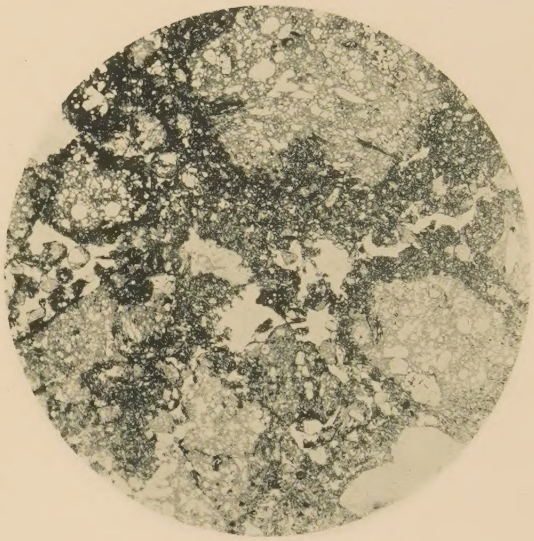
2.



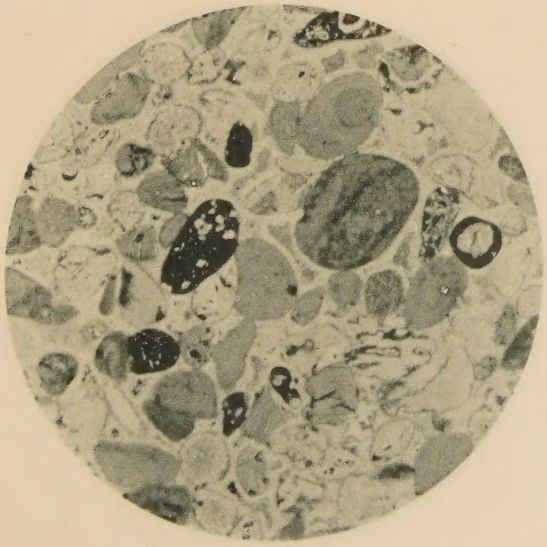
3.



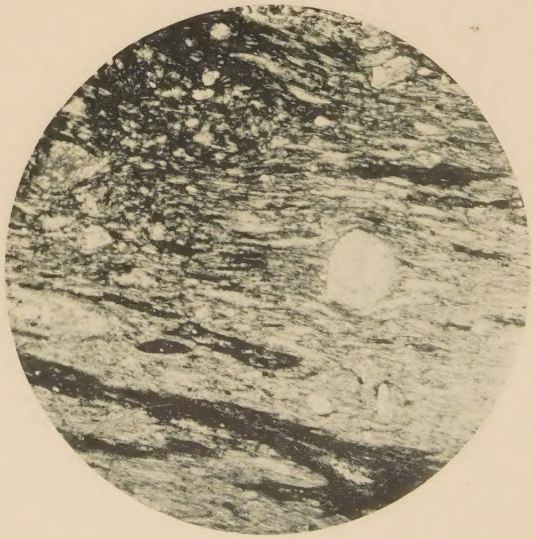
4.



5.



6.



7.